যন্ত্রকৌশলের যন্ত্রণা

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বা পারবো? আমার কখনো কখনো মনে হয় আমরা ইঞ্জিনিয়ারিং বিদ্যা রপ্ত করি ইঞ্জিনিয়ারিংটাকে ভালোভাবে ব্যবহার করতে, আবিষ্কার করতে নয়। অনেকেই আমার এই কথাটাকে একবাক্যে অস্বীকার করবেন, কিন্তু আপনি ভালো করে ভেবে বলুন তো, আপনি এই বইটা কেন পড়ছেন? কারণ আপনি একটা ভালো চাকুরি পাবার জন্য প্রস্তুতিমূলক বই হিসাবে নিচ্ছেন এই বইটাকে। আর চাকুরি করতে গেলে অধিকাংশক্ষেত্রে আমি, আপনি, আমরা সবাই ইঞ্জিনিয়ারিংটাকে ব্যবহার করবো, যন্ত্রের মেইনটেনেন্স করবো। এটা আমি আমাদের দেশের প্রেক্ষাপট হিসেবে বললাম। কিছু ক্ষেত্রে একটা অংশ গবেষণামুখী, আবিষ্কারমুখী। বাকিক্ষেত্রে সবাই আবিষ্কারের ব্যবহারকে সুষ্ঠু ও দীর্ঘস্থায়ী করার লক্ষ্যে কাজ করি।

আসলে এতক্ষণ আমি যন্ত্রকৌশলের পরে 'যন্ত্রণা' কথাটাযুক্ত করার ব্যাপারটা ব্যাখ্যা করার চেষ্টা করলাম। ব্যবহার যন্ত্রণার হলেও হতে পারে কিন্তু আবিষ্কারটা অবশ্যই মজাদার। আমরা যন্ত্রকৌশলীরা এই মজাদার বিদ্যাটাকে কখনোই যন্ত্রণাদায়ক বলতে পারিনা। এই যন্ত্রকৌশল রপ্ত করতেই আমাদের এমন কাহিল অবস্থা হয় যার দরুন আমরা একে যন্ত্রণা-কৌশল বলি। অথচ যখন পেশাগত কারণে শতশত যন্ত্রের ব্যবহার করি তখন কি একবারও মনে হয় না, এই যন্ত্রটা কিভাবে তৈরি হয়েছে? কোন অংশে কোন থিওরি ব্যবহার করা হয়েছে? যখন একজন যন্ত্রকৌশলী তার পেশাটাকে অন্তরে ধারণ করেন তখন উনি এই আবিষ্কারের আসল স্বাদ পেয়ে যান। আর অন্তরে ধারণ করতে ভালবাসতে হয়।

বাংলাদেশে যন্ত্রকৌশলের চাকুরির ক্ষেত্রসমূহ

সরকারি/স্বায়ত্তশাসিত প্রতিষ্ঠানসমূহ

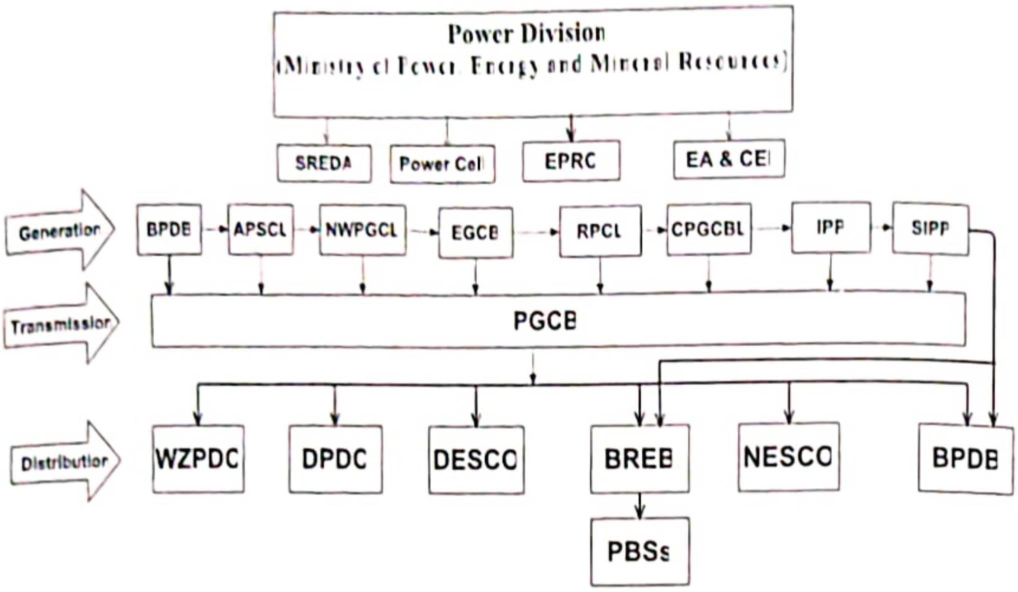
" চাকুরি যখন করবো তখন সরকারি চাকুরীই করবো। একটু সময় দিয়ে প্রস্তুতি নিয়ে হলেও সরকারি চাকুরীটাই করতে হবে আমাকে। "

" নাহ। অনেক হয়েছে। আর নয়। পাশ করেই একটা চাকুরী দরকার। হোক সেটা বেসরকারি। আমি তাতেই খুশি। "

আমাদের দেশের পাশ করা প্রকৌশলীদের মধ্যে দুইধরনের আকাঙ্ক্ষাই লক্ষ্যনীয়। একটা সময় ছিল সরকারি চাকুরিতে যাওয়ার ক্ষেত্রে অনেকের মধ্যেই কিছুটা অনীহা কাজ করতো। এর মূলে ছিল কম বেতন। কিন্তু চাকুরীর নিরাপত্তার ক্ষেত্র বিবেচনা করলে সবার পছন্দের না হলেও আগ্রহের জায়গা ছিল সরকারী চাকুরি। তবে বর্তমানে নিরাপত্তার সাথে উচ্চমান বেতন আর পেশাগত ক্ষমতা বৃদ্ধি প্রকৌশলীদেরকে বহুগুণে আগ্রহী করে তুলেছে।

পাঠক পছন্দই বলি আর প্রকৌশলীদের পছন্দই বলি, তালিকায় যেহেতু সরকারি চাকুরীর ক্রমই প্রথমে তাহলে সেটা নিয়েই আগে আলোচনা করা যাক।

বিদ্যুৎ আর গ্যাস। এই দুইয়ের উপর সবার নজর। বিদ্যুৎখাতে সরকারের লক্ষ্যমাত্রা বাড়ার সাথে সাথে চাকুরীর ক্ষেত্রও বাড়ছে। এক ঢিলে দুই পাখি মারার ব্যবস্থা করা যাক। শুধু প্রতিষ্ঠানের নাম না জেনে একটু ছক আকারে জানার চেষ্টা করি তাহলে চাকুরী ভাইভাতে কাজে দিতে পারে।

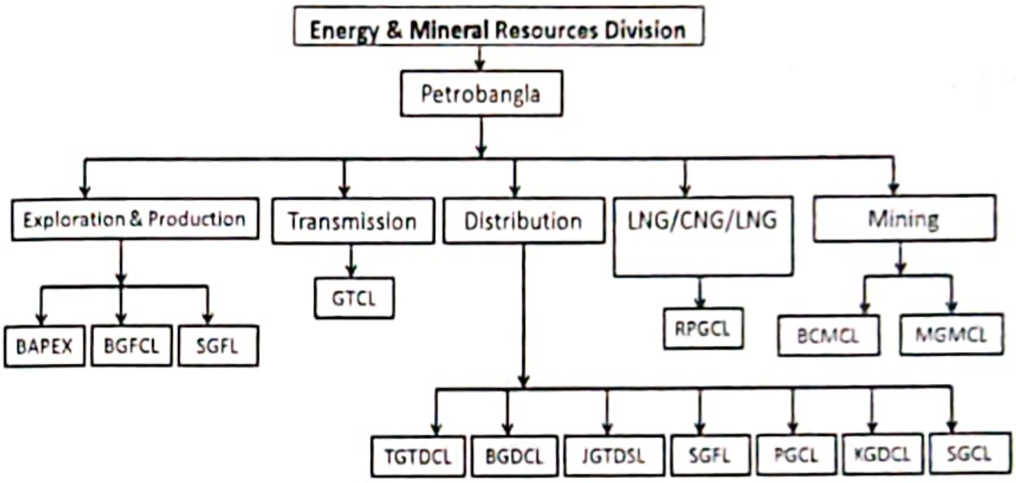


উপরের সকল প্রতিষ্ঠানেই প্রতিবছর কমবেশি যন্ত্রকৌশলীদের জন্য চাকুরীর নিয়োগ বিজ্ঞপ্তি আসে।

বিদ্যুৎ সেক্টরের এই বিশাল রাজ্যে আরো একটা প্রতিষ্ঠান যুক্ত হয়েছে- *রূপপুর পারমাণবিক বিদ্যুৎ কেন্দ্র*। এই প্রতিষ্ঠানে প্রতিবছর গড়ে শতাধিক প্রকৌশলী নিয়োগ দিচ্ছে। আশা করা যায় আরো বেশ কয়েক বছর এই পরিমাণ প্রকৌশলী নিয়োগ দিতে থাকবে এই প্রতিষ্ঠানটি। এর বাইরেও দেশে অনেক কয়লাভিত্তিক বিদ্যুৎ উৎপাদন কেন্দ্র স্থাপন করা হচ্ছে। কয়লাভিত্তিক এই বিদ্যুৎ উৎপাদন কেন্দ্রগুলোও নিয়োগ দিচ্ছে। উক্ত প্রতিষ্ঠানগুলো কিছু কিছু পুরোপুরি সরকারি আর কিছু কিছু স্বায়ত্তশাসিত।

বিদ্যুৎ সেক্টর নিয়ে বর্তমানে দেশের যা অবস্থা তাতে বাড়াবাড়ি পর্যায়ে বললেও অপরাধ হবে না বা ভুল বলা হবে না। সত্য জানতে হলে কাছে যেয়ে জানতে হবে না। ইউটিউব বা গুগলে সার্চ দিলেই বুঝা যাবে পায়রা বা মাতাড়বাড়িতে কি ঘটছে। বলা হচ্ছে দেশের অন্যতম পাওয়ার হাব বা পাওয়ার অঞ্চল হতে যাচ্ছে এই এলাকা দুইটি। সরকারি বা স্বায়ত্তশাসিত প্রতিষ্ঠানগুলোর সাথে জয়েন্ট ভেঞ্চারে কিছু কিছু প্রতিষ্ঠান দ্রুত দেশের বিদ্যুৎখাতে যুক্ত হওয়ার সাথে সাথে প্রকৌশলীদের জন্যও কর্মের ঠিকানা হয়ে যাত্রা শুরু করেছে। এবং এই যাত্রা সত্যিকার অর্থে যান্ত্রিক প্রকৌশলীদের জন্য অবশ্যই আশীর্বাদ।

আগেই বলেছি গ্যাস সেক্টরও প্রকৌশলীদের চাকুরির একটা বড় ক্ষেত্র। পেট্রোবাংলার আওতাধীন কোম্পানীগুলোর নাম একটা ছক আকারে তুলে ধরা যাক। প্রতিবছর এই প্রতিষ্ঠানগুলো কমবেশি অনেক যন্ত্রকৌশলী নিয়োগ দিয়ে থাকে। তবে এগুলো প্রতিষ্ঠানের বেতন কাঠামো বিদ্যুৎ কোম্পানীগুলোর সাথে তারতম্য আছে।



উক্ত মন্ত্রণালয়ের অধীনে এইরকম আরো একটি প্রতিষ্ঠান *Bangladesh Petroleum Corporation (BPC)* এবং এর অধীনস্থ প্রতিষ্ঠানসমূহ হলো- *ERL, POCL, JOCL, MPL, LPGL, ELB, SAOCL.* এই প্রতিষ্ঠানসমূহও আলাদা আলাদা নিয়োগ দিয়ে থাকে।

এতক্ষণে যন্ত্রকৌশলের জাহাজে যেসব যাত্রী উঠেছেন তারা হয়তো বুঝে গেছেন আসলে কতগুলো প্রতিষ্ঠানে চাকুরি হতে পারে। সবে তো শুরু। এখন আরো কিছু প্রতিষ্ঠানের নাম জানা যাক যেসব প্রতিষ্ঠান আমরা সবাই চিনি-জানি তবুও এখনকার জানাটা একটু দৃষ্টিভঙ্গি পাল্টিয়ে জানা। মানে কর্মের তাগিদে জানা। প্রতিষ্ঠানগুলো দুই-এক বছর পর পরই নিয়োগ বিজ্ঞপ্তি প্রকাশ করে। যেমনঃ *WASA, RAJUK, BWDB, BADC, BCIC, BIWTA, BITAC, BSEC, BEPZA, BOF, BCSIR, BSFIC, BSRI, BJMC, Bangladesh Tea Board, BFDC, BRTA, DMTCL, BAF, Bangladesh Army, NAVY, বাংলাদেশের সকল ব্যাংক, পিএসসির আওতাধীন শিক্ষা প্রতিষ্ঠান, নন ক্যাডার, বিসিএস ক্যাডার, বিভিন্ন মন্ত্রণালয় ইত্যাদি।* এছাড়াও আমরা যেসব ইঞ্জিনিয়ারিং বিশ্ববিদ্যালয় বা পাবলিক বিশ্ববিদ্যালয় দেখছি এইসব

প্রতিষ্ঠানে ইঞ্জিনিয়ারিং সেকশন বলে একটা আলাদা বিভাগ থাকে। এসব বিভাগেও মাঝে মাঝে নিয়োগ দেওয়া হয়। সিটি করপোরেশনগুলোতেও একই অবস্থা। এই রকম আরো অনেক প্রতিষ্ঠান আছে। সার কারখানাগুলো সম্পর্কে বলিনি দেখে অনেকে যারা একটু থমকে দাঁড়ালেন তাদের জন্য বলে রাখি এইগুলো *BCIC* এর আওতাধীন প্রতিষ্ঠান। এই নিয়োগগুলো একসাথেই হয় সচরাচর। এছাড়াও দেশে নতুন নতুন প্রজেক্ট আসছে নতুন নতুন প্রতিষ্ঠান যাত্রা আরম্ভ করছে।

বেসরকারি প্রতিষ্ঠান সমূহ

যদি এইসব শতাধিক সরকারি/স্বায়ত্তশাসিত প্রতিষ্ঠানসমূহে প্রতিবছর গড়ে দেড়'শ বা দুই'শ জনও যান্ত্রিক প্রকৌশলী নিয়োগ দেওয়া হয় তবুও বার্ষিক পাশকৃত সকল যন্ত্রকৌশলীদের সরকারি চাকুরি হওয়া সম্ভব নয়। আরো প্রাসঙ্গিক ব্যাপার হলো ত্রিশ বছর বয়স পর্যন্ত সবাই চেষ্টা করে সরকারি চাকরির জন্য এবং এতে করে যেকোন যন্ত্রকৌশল নিয়োগ পরীক্ষায় দেখা যায় দুই-তিন হাজার পরীক্ষার্থী পরীক্ষা দিতে আসে। গত তিন চার বছরের চাকরির এসব নিয়োগ পরীক্ষা দেখে এটা খুব অনুমেয় যে অধিকাংশ পরীক্ষার্থী কোন না কোন বেসরকারি চাকুরিতে নিয়োজিত থেকে পাশাপাশি সরকারি চাকরিরর চেষ্টা করছে। বাস্তব হলো যদি ত্রিশ বছর অবধি কোন সরকারি চাকুরি না হয় অথবা কেউ স্বেচ্ছায় সরকারি চাকুরি না করে তাহলে অবশ্যই তারা বেসরকারি চাকুরিতেই মনোনিবেশ করে।

সরকারি/স্বায়ত্তশাসিত প্রতিষ্ঠানসমূহের তালিকা যত সহজে তৈরি করা যায় বেসরকারি প্রতিষ্ঠানের তালিকা তত সহজে করা সম্ভব নয়। কেন সম্ভব নয় তার একটা উদাহরণ দেওয়া যাক। কিছুদিন আগে এক জ্যেষ্ঠজন একটা বিজ্ঞপ্তি দেখালেন যেখানে বলা হচ্ছে কিছু প্রকৌশলী প্রয়োজন তাদের প্রতিষ্ঠানের জন্য, আর প্রতিষ্ঠানটির পরিচয় সোজাসাপ্টা বললে সেটা ছিল চট্টগ্রামের একটা গরুর খামার। তবুও মোটামুটি একটা ধারণা নেওয়া যাক। আবারো বিদ্যুৎ সেক্টর দিয়েই শুরু করা যাক। বাংলাদেশে এখন পর্যন্ত মোট বিদ্যুৎকেন্দ্রের সংখ্যা ১৩৭ টি। যার মধ্যে বেসরকারি বিদ্যুৎকেন্দ্র নেহায়েৎ কম নয়। *Summit Power, MAX Power, Desh Energy, Haripur (Pendekar), Meghnaghat (Pendekar), NEPC (Pendekar), Orion, Doreen, APR Energy, Aggreco, United, Confidence, Bangla Track, Sinha, Raj Lanka* সহ অনেক বেসরকারি বিদ্যুৎকেন্দ্র রয়েছে। এগুলোসহ বাকি অন্য সবগুলো বিদ্যুৎকেন্দ্রের নাম, উৎপাদন ক্ষমতাসহ যাবতীয় অন্যান্য তথ্যাবলী পিডিবির ওয়েবসাইটের (*http://www.bpdb.gov.bd*) উৎপাদন সেকশনে পাওয়া যাবে। সিরাজগঞ্জে আরো একটি নতুন পাওয়ার প্ল্যান্ট হিসেবে যাত্রা শুরু করেছে *Semcorp Power.*

বেসরকারি গ্যাস কোম্পানীগুলোর মধ্যে রয়েছে *Chevron, Orion, Petromax, Navana, Bashundhara, Omera, Linde* ইত্যাদি। এছাড়াও *Petromax* এর oil refinery রয়েছে।

যন্ত্রকৌশলীদের জন্য Pharmaceutical গুলোতে চাকুরির বড় একটা ক্ষেত্র রয়েছে। ফার্মেসীতে ওষুধ কিনতে গেলে আমরা আগে দেখি এটা কি *Square* এর? *Beximco* নাকি *Incepta*? আমাদের সেই সুপরিচিত Pharmaceutical গুলোই আমাদের চাকুরিক্ষেত্র। যন্ত্রকৌশলীদের অনেকেই আছেন যাদেরকে Pharmaceutical মুখী career এ স্থায়ী হতে দেখা গিয়েছে। একইভাবে *Reneta, Opsonin, Eskayef, Beacon Pharma, Genvio Pharma, ACI Pharma* সহ অন্যান্য Pharmaceutical কোম্পানীগুলোতে যন্ত্রকৌশলীদের চাকুরির সুযোগ রয়েছে।

দেশে এখন অটোমোবাইল কোম্পানীও বেশ কয়েকটি। *Runner Motors, Nitol Niloy, Walton* সহ বেশ কিছু প্রতিষ্ঠান আছে যেগুলো যন্ত্রকৌশলীদের নিয়োগ দেয়।

Beverage & Food কোম্পানীগুলোর মধ্যে *PRAN Group, Transcom, Square, Akij, Partex, Olympic* এরমত অনেক প্রতিষ্ঠানই আছে যন্ত্রকৌশলীদের জন্য। প্লাস্টিক কোম্পানীগুলোর মধ্যে রয়েছে *RFL, Bengal, EBL, N-Poly* ইত্যাদি। *Walton, Minister, LG, Rohimaafroz, EnergyPac, Bangla Cat* এই কোম্পানীগুলোতে যন্ত্রকৌশলীদের জন্য খুব ভালো সুযোগ হয়। স্টীল মিলসগুলোর মধ্যে রয়েছে- *BSRM, KSRM, Abul Khair* ইত্যাদি। *Heidelberg cement, Lafarge Holcim, Crown Cement* সহ অন্যান্য সিমেন্ট কোম্পানীগুলোতেও যন্ত্রকৌশলীদের চাকুরীর সুযোগ আছে। সকল ইপিজেডসহ দেশী-বিদেশী গার্মেন্টস যান্ত্রিক প্রকৌশলীদের ভালো একটা ক্ষেত্র।

বাংলা কোম্পানীগুলোর পাশাপাশি প্রাইভেট সেক্টরে জবের প্রসঙ্গ আসতেই সবার দৃষ্টি থাকে Multinational company গুলোর দিকে। যেমনঃ *Unilever, GSK, Chevron, BAT, Nestle, Berger Paints, Asian Paints, RAK paints, Wartsila, ABB, GE, Siemens, Samsung* ইত্যাদি।

প্রাইভেট এসব কোম্পানীর তালিকা খুব ছোট নয়। আরো অনেক অনেক কোম্পানী রয়েছে। তাদের মধ্যে *KAFCO*, বিভিন্ন ধরনের কেমিক্যাল কোম্পানী যেমনঃ *Samuda Chemicals, Tasnim Chemicals,* বিভিন্ন ধরনের Ship Building কোম্পানী এর মধ্যে আছে, *Western Marine, Ananda Shipyard, Marine House* ইত্যাদি।

দেশে যেসব বড় বড় প্রজেক্টগুলোর কাজ চলছে এইসব প্রজেক্টের জন্য যেসব কন্সট্রাকশন কোম্পানী কাজ করে তারা দেশে অনেক প্রকৌশলী নিয়োগ দিয়ে থাকে। যেমনঃ *Siemens, Samsung* এই ধরনের কোম্পানীগুলো বড় বড় পাওয়ার প্ল্যান্ট প্রজেক্টগুলোতে কাজ করে।

যন্ত্রকৌশল চাকুরির প্রস্তুতি

চাকুরির প্রস্তুতি বলতে এখানে সরকারি বা স্বায়ত্তশাসিত প্রতিষ্ঠানে নিয়োগের জন্য পরীক্ষা পদ্ধতি বা প্রশ্নের ধরণ বা মার্কস ডিসট্রিবিউশন নিয়ে আলোচনা করা হচ্ছে। আর এইসব পরীক্ষার জন্য নিজেকে প্রস্তুত করতে পারলে প্রাইভেট চাকুরির জন্য আলাদা কোন প্রস্তুতি নিতে হবে না।

কিভাবে শুরু করবো?

শুরুতেই বিভিন্ন চাকুরি পরীক্ষার প্রশ্নগুলো সম্পর্কে একটা ধারণা নেওয়া উচিত। বিভিন্ন পরীক্ষার পূর্বের বছরের প্রশ্নগুলোর ধরণ দেখে নিলে কিভাবে প্রস্তুতি নিতে হবে তার উপর মোটামুটি একটা ধারণা পাওয়া যাবে। এরপর একটা লিস্ট বানিয়ে ফেলতে হবে কোন কোন সাবজেক্টগুলো পড়া লাগবে। উক্ত সাবজেক্টগুলোর জন্য কোন কোন লেখকের বই পড়তে হবে সেগুলো সংগ্রহ করতে হবে।

পরীক্ষা কেন্দ্রের উপর নির্ভর করবে প্রস্তুতির ধরন!

মেকানিক্যালের অধিকাংশ চাকুরির পরীক্ষা BUET-এ অনুষ্ঠিত হয়ে থাকে। কিছু কিছু পরীক্ষা হয় MIST তে। আবার কোন কোন পরীক্ষার প্রশ্ন ঢাকা বিশ্ববিদ্যালয়ের IBA ডিপার্টমেন্ট করে থাকে। BPSC- এর সকল পরীক্ষার প্রশ্ন BPSC-এর সিলেবাসেই হয়। কিছু কিছু প্রতিষ্ঠান BUET বা MIST ছাড়াও মাঝে মাঝে নিজেরাই পরীক্ষা নিয়ে থাকে। যেমনঃ REB, BIWTA ইত্যাদি। আবার কিছু পরীক্ষার প্রশ্ন প্রতিষ্ঠানের অবস্থান ভেদে রুয়েট, কুয়েটেও হয়ে থাকে। তবে সবগুলো প্রতিষ্ঠানের প্রশ্নের ধরণ কিছুটা একই রকম। সেক্ষেত্রে ভিন্নতা বলতে কোথাও নৈর্ব্যক্তিক প্রশ্ন হয় আবার কোথাও লিখিত হয়। আবার মাঝে মাঝে REB নৈর্ব্যক্তিক, লিখিত দুই-ই নিয়ে থাকে।

চাকুরিজীবীদের প্রস্তুতির জন্য একটু বেশি কষ্ট করতে হবে।

মধ্যবিত্ত পরিবারের সবারই কম বেশি পাশ করেই আগে চাকুরি করার একটা তাড়া থাকে। আর সেজন্য সবারই কষ্ট করতে হয়। এটাকে খুব স্বাভাবিকভাবেই নেওয়া উচিত। এসব ক্ষেত্রে ভালো ভাবে নিজের এন্ড্রয়েড ফোনের ব্যবহার করা যেতে পারে। অফিসে যাওয়া আসার সময় ফোনে কিছু পড়াশুনা করার অভ্যাস তৈরি করা যেতে পারে। বাসা থেকে বের হওয়ার সময় ফোনে বইয়ের দুই-চারটা পেজ ছবি তুলে নিয়ে বের হলে ভালো হয়। সাধারণ জ্ঞান চর্চার জন্য কিছু ওয়েব সাইট দেখা অথবা সাধারণ জ্ঞানের বই পড়া দরকার। সেক্ষেত্রেও ফোনের সর্বোচ্চ ব্যবহার করা উচিত। চলাফেরার মাঝে চোখ বুলাতে থাকলে বাসায় এসে দুই-এক ঘন্টা খাতা কলম নিয়ে বসলে খুব ভালো একটা প্রস্তুতি হতে থাকবে। খুবই ধৈর্যের পরিচয় দিতে হবে। চাকুরি করে বাসায় ফিরে খুব ক্লান্তিতে পড়ার ইচ্ছে হবে না এটাও যেমন স্বাভাবিক তেমনি নিয়মিত না পড়লে চাকুরি পরীক্ষায় ভালোও করা যাবে না সেটাও বাস্তব।

বুয়েটে অনুষ্ঠিত পরীক্ষার ধরণ।

বুয়েটে অনুষ্ঠিত চাকুরির পরীক্ষায় মোটামুটি দুইটা অংশ থাকে। একটা ডিপার্টমেন্টাল অংশ আরেকটা নন-ডিপার্টমেন্টাল অংশ। ডিপার্টমেন্টাল অংশে মূলত মেকানিক্যালের মূল বিষয়গুলোর উপর প্রশ্ন হয়ে থাকে। যেমনঃ Thermodynamics, IC Engine, Fluid Mechanics, Heat Transfer, Power Plant Engineering, Refrigeration and Air Conditioning, Strength of Materials, Theory of Machines, Engineering Mechanics, Machine Tool, Automobile Engineering ইত্যাদি। উক্ত বিষয়গুলো থেকে ছোট ছোট থিওরি, ডায়াগ্রাম এবং ম্যাথমেটিক্যাল প্রবলেমগুলো থাকে। সবগুলো পরীক্ষাতেই কমন বিষয় হলো ড্রয়িং। ড্রয়িংয়ে মূলত TOP VIEW, FRONT VIEW & RHS VIEW আঁকতে বলে অধিকাংশ সময়।

ননডিপার্টমেন্টাল অংশে সাধারণ জ্ঞান, সাধারণ গণিত, বাংলা, ইংরেজী, মানসিক দক্ষতা (Analytical Ability) এইসব থাকে।

মার্কস ডিস্ট্রিবিউশন

পরীক্ষাভেদে মার্কস ডিস্ট্রিবিউশনের ভেরিয়েশন হয়। পরীক্ষায় সর্বোমোট ১০০ অথবা ৮০ মার্কস থাকে। এর মধ্যে মোটামুটিভাবে ৬০% মার্কস থাকে ডিপার্টমেন্টাল প্রশ্নে আর বাকি মার্কস ননডিপার্টমেন্টাল প্রশ্নে। ডিপার্টমেন্টাল থেকে সাধারণত বারোটা বা চৌদ্দটা প্রশ্ন থাকে। আর এই প্রতিটা প্রশ্নের মান পাঁচ বা ছয় নম্বর করে। আর ননডিপার্টমেন্টাল অংশ বিভিন্ন সময় বিভিন্ন রকম হয়। কখনো ষাটটা নৈর্ব্যক্তিক থাকে। (০.৫X৬০=৩০ নম্বর)। আবার কখনো বিশটা Analytical Ability থাকে যার মান (১X২০=২০) এবং সাথে আরো চল্লিশটা নৈর্ব্যক্তিক থাকে যার মান (০.৫X৪০=২০)। এভাবে বিভিন্ন সময় প্রশ্নের তারতম্য হয়। পরীক্ষাগুলোতে মূলত দেড় ঘন্টা সময় থাকে।

বিষয়ভিত্তিক প্রস্তুতি

শুরুতেই বিগত বছরের চাকুরি পরীক্ষার প্রশ্নগুলো দেখে একটা ছক তৈরি করা যেতে পারে। ফলে প্রিপারেশন নিতে সুবিধা হবে। এজন্য পাশে থেকে সহায়ক ভূমিকা পালন করবে Fundamentals of Mechanical Engineering বইটি। তবে ছক তৈরির ক্ষেত্রে অবশ্যই শুধু মাত্র যেসব টপিক পরীক্ষায় এসেছে সেগুলো না পড়ে তার সাথে ওই রকম আরো কিছু টপিক যোগ করে পড়া উচিত। এতে করে প্রশ্নের ধরণ পরিবর্তন হলেও প্রস্তুতি অনেক ভালো থাকবে।

ননডিপার্টমেন্টাল থেকে কিভাবে পড়বো?

ননডিপার্টমেন্টালের জন্য কোন ধরাবাধা সিলেবাস নেই। তবে বিসিএস বা ব্যাংক জবের প্রস্তুতির জন্য যেসব বই বা নোট বাজারে পাওয়া যায় সেগুলো পড়লেই মোটামুটি হয়ে যাবে। তাছাড়াও কিছু ওয়েব সাইট থেকে নিয়মিত ননডিপার্টমেন্টাল বিষয়গুলো পড়াশুনা করা যেতে পারে। যেমনঃ engineerscafebd.com, indiabix.com, examveda.com, readbd.com ইত্যাদি।

বুয়েটের বাইরের প্রস্তুতি কিভাবে নিবো?

বুয়েটের বাইরে যেসব পরীক্ষা হয় তার অধিকাংশই MIST এর আন্ডারে অথবা DU এর IBA এর আন্ডারে হয়। MIST তে মোটামুটিভাবে বুয়েট ভিত্তিক প্রস্তুতি থাকলেই হবে। আর IBA এর আন্ডারে পরীক্ষাগুলোর ক্ষেত্রে Departmental MCQ থাকে আর এজন্য R. S. Khurmi এর লেখা Conventional Mechanical Engineering বইটা পড়া যেতে পারে। IBA এর আন্ডারে পরীক্ষাগুলোতে ডিপার্টমেন্টাল প্রশ্ন ৫০% আর ননডিপার্টমেন্টাল প্রশ্ন ৫০% হয়ে থাকে। তবে ৬০%+৪০% মার্কস ডিসট্রিবিউশনও হয়। এরজন্য IBA এর ভর্তি পরীক্ষার প্রশ্নগুলোর মত ননডিপার্টমেন্টাল প্রশ্নগুলো পড়া ভালো। সাথে বিসিএসের প্রস্তুতির মত বাংলা, ইংরেজী, সাধারণ জ্ঞান এসব।

প্রতিদিন কত ঘন্টা পড়বো?

প্রতিদিন যে যত সময় দিতে পারবে তার তত দ্রুত প্রস্তুতি সম্পূর্ণ হবে। চাকুরিজীবী হলেও প্রতিদিন দুই-এক ঘন্টা ন্যূনতম পড়াশুনা করা দরকার। আর যারা চাকুরি করেন না তাদের জন্য দিনের সর্বোচ্চ সময়টা প্রস্তুতির জন্য ব্যবহার করতে পারেন।

কতদিন পড়া লাগবে? কয়টা ভাইবা দেওয়া লাগবে!!

কতদিন পড়া লাগবে আর কয়টা ভাইভা দেওয়া লাগবে এই ব্যাপারটা আপেক্ষিক। কারণ কারো যদি সব সাবজেক্টে খুব ভালো দখল থাকে তাহলে তার সময় কম লাগবে। তবে গড়ে প্রায় দুই বছর নিয়মিত পড়াশুনা করতে থাকলে একটা চাকুরি হবেই। অনেকের ছয় মাসেও হয়ে যেতে পারে। কয়টা ভাইভা দেওয়া লাগবে এই বিষয়টা প্রত্যেকের জন্য আলাদা। কেউ প্রথম ভাইভাতেই বাজিমাত করে আবার কেউ বিশতম তে। আমার একটা চাকুরি হয়েছিল পশ্চিমাঞ্চল গ্যাস কোম্পানিতে আর সেটি সম্ভবত আমার নয়তম কি দশতম ভাইভা ছিল।

আশা করি সবাই ভালো করে শুরু করতে পারবেন। শুভ কামনা রইল।

ভাইভার আদ্যপ্রান্ত

চাকুরির ভাইভা মূলত নিজেকে উপস্থাপন করার একটি সুযোগ। কথায় যেমন চিড়ে ভিজে না তেমনি সুন্দর বা উজ্জ্বল বর্ণ চেহারা থাকলেই চাকুরি হয় না। যেটাতে চাকুরি হয় সেটা হলো পরিপাটি থাকায়, গুছিয়ে উত্তর দেওয়ায়, যৌক্তিক এবং প্রাসঙ্গিক কথা বলায়। অবশ্য যেসব নিয়োগে লিখিত পরীক্ষা হয় সেসব ক্ষেত্রে এর বাইরেও লিখিত পরীক্ষা সবচেয়ে বেশি বড় প্রভাবক বা নিয়ামক। তবে যান্ত্রিক প্রকৌশলীদের বিশ্ববিদ্যালয়ে অধ্যয়নরত অবস্থায় যতবার ভাইভা বোর্ডের সম্মুখীন হতে হয় তাতে তাদের যথেষ্ঠ ভাইভা এটিকেট শেখা হয়ে যায়।

ভাইভার জন্য নিজেকে প্রস্তুত করার কয়েকটা ধাপ আছে যেগুলো অতিক্রম করতে হলে প্রয়োজন একটু স্থিরভাবে গুছিয়ে নেওয়া। ব্যক্তিগতভাবে প্রশ্ন করলে এটাই উত্তর দিব, ভাইভা দিতে আমার ভালোই লাগে। তবে চিন্তিত থাকি সাধারণ জ্ঞান নিয়ে। সাধারণ জ্ঞান নিয়ে চিন্তিত থাকি তারমানে এই নয় যে আমি টেকনিক্যাল প্রশ্ন সব পারি। আমার চিন্তার কারণ হলো সাধারণ জ্ঞানের পর্বে অনেক সময় অতি সাধারণ প্রশ্ন করে ফেলে যার উত্তর দিতে আমি অত্যন্ত অভিজ্ঞভাবে অকৃতকার্য হই। এসব পরে বিস্তারিত বলছি। ভাইভার প্রস্তুতি নিয়ে কয়েকটা পয়েন্ট আলোচনা করা যাক।

ভাইভাতে ডাক পাওয়ার পর থেকে যেভাবে প্রস্তুত করতে হবে।

যদি ভাইভার ডাক পাওয়ার পরে মনে হয় এই চাকুরিটা আমার দরকার তাহলে সেটাকে সেভাবেই মূল্যায়ন করা উচিত। অনেককেই দেখি "যাই ঘুরে আসি" টাইপের প্রস্তুতি নিয়ে যায়। চাকুরি করি বা না করি, চাকুরি হোক বা না হোক যদি ভাইভাতে উপস্থিত হই তাহলে নিজের একটা সুন্দর ব্যক্তিত্বকে উপস্থাপন করে আসবো এটা ভেবেই যাওয়া উচিত। কারণ আপনি যাচ্ছেতাই করে আসলে আপনার উপরে যেমন খারাপ ধারণা জন্মে তেমনি অনেকেই মনে করেন আপনার প্রতিষ্ঠানের ছাত্রছাত্রীদের অনেকের মাঝেই এসব বৈশিষ্ট্য আছে। সুতরাং নিজের সাথে সাথে আপনি অন্য একটা অকাজও করে আসলেন। যা বলছিলাম, যেখানে ভাইভা দিতে যাচ্ছি সেই কোম্পানি বা প্রতিষ্ঠানের ওয়েবসাইট থেকে তাদের সম্পর্কে জেনে

যাওয়া খুবই গুরুত্বপূর্ণ। সরকারি চাকুরির সহকারি প্রকৌশলী পোষ্টের জন্য একটা গতানুগতিক ভাইভা হলেও বেসরকারি প্রতিষ্ঠানের ক্ষেত্রে কোন পোষ্টের জন্য পরীক্ষা দিচ্ছি সেই পোষ্টের দায়িত্বগুলো জেনে সেভাবে টপিকগুলো পড়ে যাওয়া উচিত। আগে কেউ ওই প্রতিষ্ঠানে ভাইভা দিয়ে থাকলে সেই অভিজ্ঞতা গ্রহণ করা যেতে পারে যদি সুযোগ হয়। সরকারি বা স্বায়ত্তশাসিত প্রতিষ্ঠানসমূহে ভাইভার জন্য আলাদাভাবে সাধারণ জ্ঞানের উপর প্রস্তুতি নিতে হবে।

ভাইভার পোশাক পরিচ্ছদ

ভাইভার জন্য ভালো ড্রেস হলো এক কালারের শার্ট পড়া, জিন্স ব্যতীত ফরমাল প্যান্ট পরা। পায়ে সু-জুতা পরা। শীতের সময় কোট বা সোয়েটার পরা। যেটায় হোক পরিষ্কার এবং পরিপাটি ড্রেস পরাটায় জরুরী। তবে বিসিএস বা পিএসসির ভাইভাগুলোর জন্য অনেকেই সাদা শার্ট, কালো প্যান্ট পরতে বলেন, সেটা সেই ক্ষেত্রে অনুকরণীয়। মেয়েদের ক্ষেত্রে আমার তেমন ধারণা নেই, তবে সকল ক্ষেত্রেই অতিরঞ্জিত, ওভারস্মার্ট কিছু না পরিধান করে নিজেকে পরিচ্ছন্ন ও পরিপাটি রাখাটায় আসল কথা। ছেলেদের ক্ষেত্রে টাই পড়া না পড়া ব্যক্তিগত ব্যাপার বা স্বাচ্ছন্দ্যবোধের ব্যাপার।

ভাইভা কক্ষে প্রবেশ ও প্রবেশপূর্ব আচরণ

খুব সাধারণভাবে সালাম দিয়ে, স্যার আসবো বলে ভিতরে প্রবেশ করাটায় যুতসই। অনেকেই ইউটিউবে দেখে, May I come in sir? / Good Morning / Good Afternoon বলে প্রবেশ পর্ব শেষ করেন। এটাও চলিত আছে। তবে সরকারি প্রতিষ্ঠানগুলোতে ভাইভার ক্ষেত্রে প্রবেশের এই ব্যাপারগুলো খুব সাধারণভাবেই গ্রহণ করা যায়। এখানে খুব বেশি স্মার্টনেস না থাকলেও চলে। অনেকদূরের পথ পাড়ি দিয়ে ভাইভায় গেলে ভিতরে প্রবেশের পূর্বে সম্ভব হলে ওয়াশরুমে যেয়ে চোখে, মুখে পানির ঝাপটা দিলে একদিকে যেমন ফ্রেশ লাগে অন্যদিকে টেনশনটাও কমে। গন্তব্যে পৌঁছে সম্ভব হলে এটা করা যেতে পারে।

ভাইভা চলাকালীন সময়ে আচরণ

ভাইভায় প্রশ্নত্তোর পর্বে কিছু বিষয় খেয়াল রাখতে বলা হয়। যেমনঃ শান্ত থাকা, যথাসম্ভব গুছিয়ে কথা বলা, তাড়াহুড়ো না করে স্বাভাবিকভাবে উত্তর দেওয়া, স্বাভাবিক থাকা, প্রশ্নকর্তার দিকে মুখ ফিরিয়ে বা চোখের দিকে তাকিয়ে উত্তর দেওয়া ইত্যাদি। খুব স্বাভাবিকভাবেই যেকোন ভাইভার আগে মুখ শুকিয়ে আসতে পারে, হার্টবিট বাড়তে পারে, অনেকের গা ঘামে এরকম অনেক কিছুই হতে পারে। ভাইভায় নিজেকে এসব থেকে সামলিয়ে খুব স্বাভাবিক রাখতে পারা বড় গুণ। ভাইভা বোর্ডে বসে প্রশ্ন শোনার পর উত্তর দেওয়ার সময় সম্ভব হলে বাস্তব উদাহরণ দিয়ে বুঝিয়ে দিতে পারলে খুব ভালো হয়। আমার ব্যক্তিগত অভিজ্ঞতা থেকে বলি, আমাকে এক ভাইভায় জিজ্ঞাসা করা হলো 'এনট্রপি কি?' আমি দুই লাইন বইয়ের ভাষায় বলার চেষ্টা করলাম এবং ওই দুই লাইন বলা শেষ হতেই উদাহরণ দিতে লাগলাম- এই রুমটা যদি একটা সিস্টেম হয় আর এখানকার এসিটা যদি তাপমাত্রা তেইশ ডিগ্রী মেইনটেইন করে এবং এই দরজাটা দিয়ে রুমে মানুষজন ঢুকতে থাকলে বা বের হতে থাকলে এখানে তাপের আদানপ্রদানে ... ...। সেইবার আমি রুম থেকে বের হওয়ার সময় শুনতে পাচ্ছিলাম 'এই ছেলের কনসেপ্টগুলো ক্লিয়ার'। একবার এক চাকুরি ভাইভায় আমি টেবিল থেকে একটা ব্লক নিয়ে উদাহরণ দিতে শুরু করেছিলাম, মূলত ওই উদাহরণটায় আমার পুরো ভাইভাটাকে অনেক ভালো করেছিল এবং আমার চাকুরি হয়েছিল। আমি উদাহরণগুলো দিচ্ছি যাতে আমরা ভাইভা বোর্ডকে খুশি করার মত উত্তর দেওয়ার জন্য নিজেকে প্রস্তুত করতে পারি।

ভাইভাবোর্ড কিছুটা ফুটবল খেলার মাঠের মত। বল কাছে পেলেই যথাসম্ভব চেষ্টা করতে হবে খেলতে। একটু ভেঙ্গে বলি- যদি প্রশ্ন করা হয় 'প্রেসার এবং স্ট্রেস এর মধ্যে পার্থক্য কি?' খুব স্বাভাবিক উত্তর দিলে বলা যায় Force per unit area হলো প্রেসার আর Internal Force/ Resisting Force per unit area হলো স্ট্রেস। কিন্তু এটা বলেই থেমে না যেয়ে কেউ যদি টেবিলের উপর থেকে একটা পেপার ওয়েট বা অন্য কিছু হাতে নিয়ে অথবা কিছু না পাওয়া গেলে টেবিলের উপর আঙ্গুল দিয়ে চাপ দিয়ে বলে যে, এই আঙ্গুল দিয়ে বল প্রয়োগ করছি এই বল এবং প্রয়োগকৃত এই জায়গাটার ক্ষেত্রফলের অনুপাতই চাপ; অন্যদিকে আমি বল প্রয়োগ করার পরেও আমার আঙ্গুল টেবিলের ভিতর প্রবেশ করতে পারলো

না তারমানে টেবিল আমার প্রয়োগকৃত বলের বিপরীতে একটা বল দিচ্ছে, এই যে বলটা টেবিলের ভিতর থেকে আসছে সেই উদ্ভূত বল এবং এই ক্ষেত্রফলের অনুপাতই হচ্ছে ট্রেস। তাহলে একদিকে যেমন প্রশ্নকর্তা খুশি হবেন অন্যদিকে নিজের পরবর্তী প্রশ্নের উত্তর দেওয়ার আত্মবিশ্বাস বাড়বে। তবে অবশ্যই সকল ক্ষেত্রে বাস্তব উদাহরণ দিতে হবে এমন ভেবে চিন্তিত হবার কিছু নেই এবং জোর করে বাস্তব উদাহরণ দিতে যেয়ে নিজের খেই হারিয়ে ফেললে ব্যাপারটা হিতে বিপরীত হবে। এভাবেই ভাইভাকে নিজের আয়ত্তে রাখা যায়।

পুরো ভাইভা বোর্ডে প্রশ্নোত্তর পর্ব চলাকালীন সময়ে উপস্থিত সবার দৃষ্টি আকর্ষণ করা প্রয়োজন। উত্তর দেওয়ার সময় শান্ত থাকার পাশাপাশি সবার দিকে তাকানো উচিত।

ভাইভা শেষে স্থান ত্যাগ

ভাইভার শেষের দিকে বোর্ড যখন ভাইভা শেষ করবে তখন খুব স্বাভাবিক ভঙ্গিতে উঠে সালাম দিয়ে স্থান ত্যাগ করা যেতে পারে। অনেকে Thank you বলে বিদায় নেয়। আসার সময় নিজের ফাইল/কাগজ পত্র সঙ্গে আনার থাকলে সেগুলো ওখানে বসেই না গুছিয়ে বরং সবগুলো কাগজ/ফাইল যত্নসহকারে হাতে ধরে বের হয়ে আসা প্রয়োজন। তবে খুব সাবধানতার সাথে কাগজগুলো এক নজর দেখে নেওয়া যেতে পারে যে সব ঠিকঠাক আছে কিনা, যদি প্রয়োজন মনে হয়।

যে পাঁচটি বিষয় না জেনে সরকারি চাকুরি ভাইভাতে যাওয়া উচিত নয় ।

যেকোন ভাইভা সবসময় অনিশ্চিত প্রশ্নাধার। কখনোই নির্দিষ্ট করে বলা যাবে না প্রশ্নকর্তা কি প্রশ্ন করবেন। তবুও কিছু প্রশ্নের উত্তর জেনে যাওয়া খুবই গুরুত্বপূর্ণ।

১। প্রতিষ্ঠান সম্পর্কিতঃ

যে প্রতিষ্ঠানে ভাইভা দিতে যাচ্ছেন তার পূর্ণাঙ্গ নাম, উক্ত প্রতিষ্ঠানের সম্পূর্ণ পরিচিতি, যেমনঃ প্রতিষ্ঠানটি কোন মন্ত্রণালয়ের অন্তর্ভুক্ত, সেই মন্ত্রণালয়ের মন্ত্রী মহোদয়ের নাম, প্রতিষ্ঠানটির প্রতিষ্ঠাকাল, চেয়ারম্যানের নাম, এর কোনো অঙ্গ প্রতিষ্ঠান আছে কিনা ইত্যাদি। এছাড়াও প্রতিষ্ঠানটি কি ধরনের সেবা প্রদান করে থাকে, উৎপাদন ক্ষমতা কত, (যদি উৎপাদনকারী প্রতিষ্ঠান হয়), উক্ত প্রতিষ্ঠানের মিশন-ভিশন কি ইত্যাদি। এছাড়াও যে প্রতিষ্ঠানে ভাইভা দিতে যাওয়া হচ্ছে সেই প্রতিষ্ঠানের আনুষঙ্গিক তথ্যাবলী জেনে যাওয়া উচিত।

২। নিজ এলাকা সম্পর্কিতঃ

কোন জেলায় বাড়ি, সেই জেলা কিসের জন্য বিখ্যাত, জেলাটির দর্শনীয় স্থান সমূহ, সেই স্থানগুলোর বিবরণ, জেলাটির নদীর পরিচয়, জেলাটি মুক্তিযুদ্ধের সময় কত নম্বর সেক্টরে ছিল, সেখানকার বিশেষ ব্যক্তিত্ব/ রাজনৈতিক নেতাদের পরিচয় এসব তথ্যাবলী জেনে যাওয়া উচিত। তবে একটু পরামর্শ দিয়ে রাখি- এই প্রশ্নগুলোর উত্তর একটা ডাইরীতে লিখে রাখা যেতে পারে যাতে প্রয়োজনের সময় পাওয়া যায়।

৩। সাধারণ জ্ঞানঃ

মুক্তিযুদ্ধ সম্পর্কিত, জাতির জনক বঙ্গবন্ধু শেখ মুজিবুর রহমান সম্পর্কিত, মহাদেশের নাম, বিশেষ বিশেষ দেশের নাম ও রাজধানী, জাতীয় চারনেতা, বীরশ্রেষ্ঠদের পরিচিতি। এছাড়াও সাধারণ জ্ঞানের উপর যার যত দখল তার তত সুবিধা।

৪। সমসাময়িক ঘটনাবলীঃ

যেদিন ভাইভা দিতে যাচ্ছেন সেদিন বাংলা কত তারিখ, সেইদিনের কয়েকটা পত্রিকার শিরোনামসহ সমসাময়িক বিষয়াবলী যতটা পারা যায় জেনে যাওয়া ভালো।

৫। বিষয়ভিত্তিকঃ

সবচেয়ে বড় দখল থাকতে হয় নিজের পাঠ্য বিষয়ের উপর। যদি কেউ কোনো চাকুরি করা অবস্থায় ভাইভা দিতে যান তাহলে সবচেয়ে বেশি সম্ভবনা থাকে বর্তমান চাকুরির বিষয়বস্তুর উপর প্রশ্ন হওয়ার। তাই বর্তমান চাকরির কাজের ক্ষেত্র সম্পর্কে খুবই ভালো করে পড়াশোনা করে যাওয়া উচিত।

অধ্যায় ২
Thermodynamics

বিষয়ভিত্তিক আলোচনা

আগেই বলে রাখি এসব কাস্টমাইজড বই পড়ে কখনোই শতভাগ প্রস্তুতি নেওয়া সম্ভব নয়। আবার অন্য সেন্সে বললে যত প্রস্তুতিই গ্রহণ করা হোক না কেন কখনোই প্রশ্নকর্তার মনের প্রশ্নগুলো শতভাগ জানা থাকবে এমন নাও হতে পারে। তবে এই বইটা পাশে রাখার জন্য যেটা হবে তা হলো পরীক্ষার আগে কি পড়বো বা কোথায় থেকে পড়বো এই দুঃশ্চিন্তার একটা সহজ সমাধান হবে। অথবা সময় কম কিন্তু কিছু পড়তে হবে এই জন্য অন্তত মানসিক মনবল বাড়াতে এই বইটা সহায়ক হবে আশা করি।

এখানে আবারো বলি আলোচনা করলে একটা পুরো বই আলোচনা করা যেতে পারে, কিন্তু তাহলে এই বইয়ের বিশেষত্ব থাকবে না। তাই কয়েকটি থার্মোডাইনামিক্স বইয়ের আলোচনা থেকে কিছু চুম্বক অংশ তুলে ধরা হলো যেগুলো ভাইভায় প্রশ্ন হতে পারে।

1. Thermodynamics Law-গুলো বলো।

Answer: Zeroth Law of Thermodynamics: When two systems are each in thermal equilibrium with a third system, then the two systems are also in thermal equilibrium with one another.

First Law of Thermodynamics: a) The heat and mechanical work are mutually convertible. i.e. $\oint dQ = \oint dw$

b) The energy can neither be created nor destroyed though it can be transformed from one to another form. i.e. $\delta Q - \delta W = \delta E$

Second Law of Thermodynamics:

Kelvin-Planck Statement: It is impossible to construct an engine working in a cyclic process whose sole purpose is to convert heat energy into an equivalent amount of work.

Clausius Statement: It is impossible for a self-acting machine working in a cyclic process to transfer heat from a body at a

lower temperature to a body at a higher temperature without the aid of an external agency.

Third law of thermodynamics: The entropy of a perfect crystal at absolute zero is exactly equal to zero.

* এই সূত্রগুলো কি প্রকাশ করে?

Zeroth Law তাপমাত্রা প্রকাশ করে, **First Law** energy প্রকাশ করে এবং **Second Law** এন্ট্রপি প্রকাশ করে ।

2. **Third law of thermodynamics কাকে বলে? এটার লিমিটেশনগুলো কি? এর গুরুত্ব কি?**

Answer : The third law of thermodynamics states that:

"The entropy of a perfect crystal of each element and a compound is zero at absolute zero."

Limitations: If any disorder like impurity or imperfection is found in a substance then the entropy of such crystal is non-zero at 0 K. For example: The entropy of pure carbon dioxide and nitric oxide is zero at 0 K. This shows that there exists disorder in the arrangement of such molecules.

This law is applicable only to pure compounds. Thus we can say that, this law is not applicable to glass which is a supercooled liquid. It is also not applicable to amorphous substance and supercooled solutions.

Importance:

a) With the help of this law Thermodynamic properties can be calculated and chemical affinity can be measured.
b) This law helps in explaining the behaviour of solids at very low temperature.

3. **Isolated System, Open System এবং Closed System বলতে কি বুঝ উদাহরণসহ বলো।**

Answer: Isolated system: A system that can neither exchange matter nor heat with the surrounding is known as an isolated system.

Example: Water placed in a vessel that is closed as well as insulated.

Open system: A system that can exchange both matter and energy with the surrounding is said to be an open system.

Example: A reaction taking place in an open vessel exchanges both energy and matter with the surrounding.

Closed system: A system that exchanges only energy and not matter with the surrounding is said to be a closed system.

Example: A reaction taking place in a closed metallic vessel.

4. System, surroundings এবং **boundary** ব্যাখ্যা করো।

Answer: A **system** is defined as a quantity of matter or a region in space chosen for study.

The mass or region outside the system is called the **surroundings**.

The real or imaginary surface that separates the system from its surroundings is called the **boundary**.

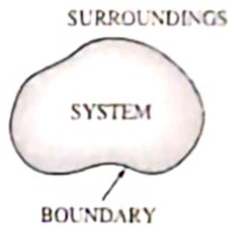


Fig.: System, Surroundings and Boundaries

5. Closed system এবং **isolated system** এর মধ্যে কি কোন পার্থক্য আছে?

Answer: হ্যাঁ পার্থক্য আছে। In a closed system, no mass can enter or leave,but energy, in the form of heat or work, can cross the boundary; and the volume of a closed system does not have to be fixed. But in an isolated system even energy is not allowed to cross the boundary.

6. What is difference between Adiabatic process and Polytropic process?

Answer: The key difference between adiabatic and polytropic processes is that in adiabatic processes no heat transfer occurs whereas in polytropic processes heat transfer occurs. Moreover, the equation $dQ=0$ is true for the adiabatic process while the equation PV^n=constant is true for the polytropic process.

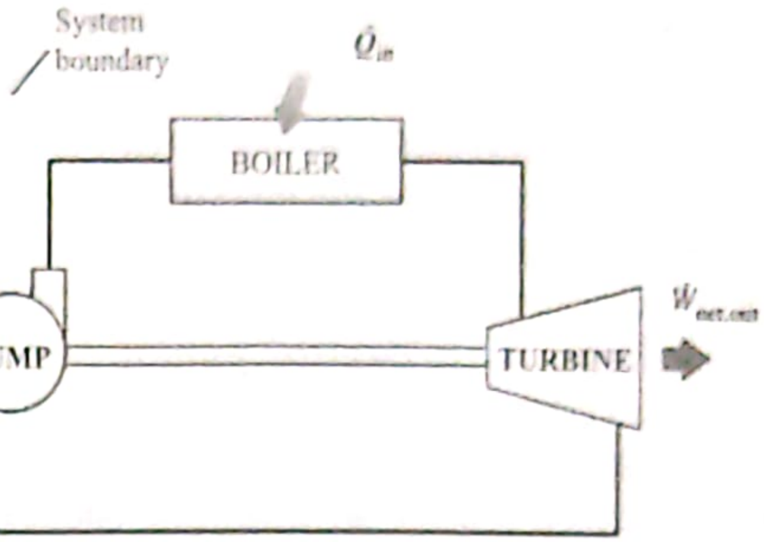


Fig.: PMM2

এখন আরো একটু আলাদাভাবে ভাবা যাক। যদি Turbine এর exhaust steam কে condenser না দিয়ে সরাসরি pump এর input হিসাবে ব্যবহার করা হয় তাহলে তো শতভাগ energy কে ব্যবহার করা যাবে। এবং যদি ২০% energy heat losses and friction এর জন্য ব্যয় হয় তবুও ৮০% থাকে। কিন্তু thermodynamics second law এই ধরনের মেশিন কখনোই মেনে নেয় না। তাই একে PMM2 বলে।

16. Entropy কাকে বলে?

Answer: The measure of the level of disorder in a closed but changing system, a system in which energy can only be transferred in one direction from an ordered state to a disordered state is called entropy. Higher the entropy, higher the disorder and lower the availability of the system's energy to do useful work. The change of entropy is expressed as–

$ds = \frac{dQ}{T}$ Where, ds = change of entropy.

17. Property কাকে বলে?

Answer: Any characteristics of a system in equilibrium is called a property, the property is independent of the path used to arrive at the system condition.

Some thermodynamic properties are pressure P, T, V and m.

Properties – 2 types (i) intensive and (ii) Extensive

(i) **Intensive Properties**: Intensive properties are those that are independent of size (mass) such as T, P, age, color or any mass independent property.

7. What is the difference between isentropic and adiabatic?

Answer: Isentropic means no change in entropy ($\oint dS = 0$). An adiabatic process is a process with no heat transfer ($\oint dQ = 0$). We defined for reversible processes $\oint TdS = dQ$. So generally an adiabatic process is not necessarily isentropic only if the process is reversible and adiabatic we can call it isentropic. For example a real compressor can be assumed adiabatic but is operating with losses. Due to the losses the compression is irreversible. Thus the compression is not isentropic.

8. What is the difference between isolated system and closed system?

Answer: The difference between isolated system and closed system is that the isolated systems cannot exchange both matter and energy with the surrounding but, though the closed systems cannot exchange matter with the surrounding, it can exchange the energy.

9. What is the Difference between Flash Point and Fire Point?

Answer: The difference between flash point and fire point is that the flash point describes the lowest temperature at which the ignition of a substance initiates whereas the fire point describes the lowest temperature at which the fuel continues to burn for a short time period after the initiation of the ignition. Furthermore, we can find a difference between flash point and fire point based on their values as well. That is why; the fire point is always a higher value than the flash point. In general, fire point is about 10 degrees higher than flash point of flammable liquids.

10. What is the difference between ideal gas law and real gas law?

Answer: Ideal gas law is an equation that describes the behaviour of an ideal gas. Real gas law is derived from the ideal gas law to suit the behaviour of real gases. Therefore, the key difference between ideal gas law and real gas law is that

ideal gas law describes the behaviour of a theoretical gas, whereas real gas law describes the behaviour of actually occurring gases in the universe.

11. What are the differences between Gas and Vapour?

Answer:

a. Vapour can turn back and forth into liquid and solid states but a gas cannot.
b. Gases cannot be seen while vapours are visible.
c. Vapours settle down on ground while gases do not.

12. What is difference between compressible fluid and incompressible fluid?

Answer: The main difference between compressible and incompressible fluid is that a force applied to a compressible fluid changes the density of a fluid whereas a force applied to an incompressible fluid does not change the density to a considerable degree.

13. Exergy কি?

[উত্তরগুলো ভাইভার উপযোগী করে দেওয়ার চেষ্টা করা হয়েছে এইজন্যই বাংলা মিশ্রিত]

Answer: মনে করি, একদল উদ্ভাবক একটা নতুন energy source আবিষ্কার করেছে, এই ধরুন একটা geothermal well। এসব ক্ষেত্রে প্রথমেই হিসাব করতে হয় নতুন সেই source এ ঠিক কতটা energy বিদ্যমান? এরপর হিসাব করতে হয় এই বিদ্যমান energy এর কতটুকু অংশকে আবার useful work হিসাবে পাওয়া যাবে? বাকিটুকুকে waste energy হিসাবে গণ্য করা হয়। Energy এর work potential অংশটুকুর প্রাপ্যতাকেই exergy বলে।

অর্থাৎ it would be very desirable to have a property to enable us to determine the useful work potential of a given amount of energy at some specified state. This property is exergy, which is also called the availability or available energy.

14. Nozzle এবং diffuser কাকে বলে?

Answer: A nozzle is a device that increases the velocity of a fluid at the expense of pressure. A diffuser is a device that increases the pressure of a fluid by slowing it down. That is, nozzles and diffusers perform opposite tasks. The cross-sectional area of a nozzle decreases in the flow direction for

subsonic flows and increases for supersonic flows. The reverse is true for diffusers.

15. What is PMM1 & PMM2?

Answer: A device that violates the first law of thermodynamics (by creating energy) is called a perpetual-motion machine of the first kind (PMM1), and a device that violates the second law of thermodynamics is called a perpetual-motion machine of the second kind (PMM2).

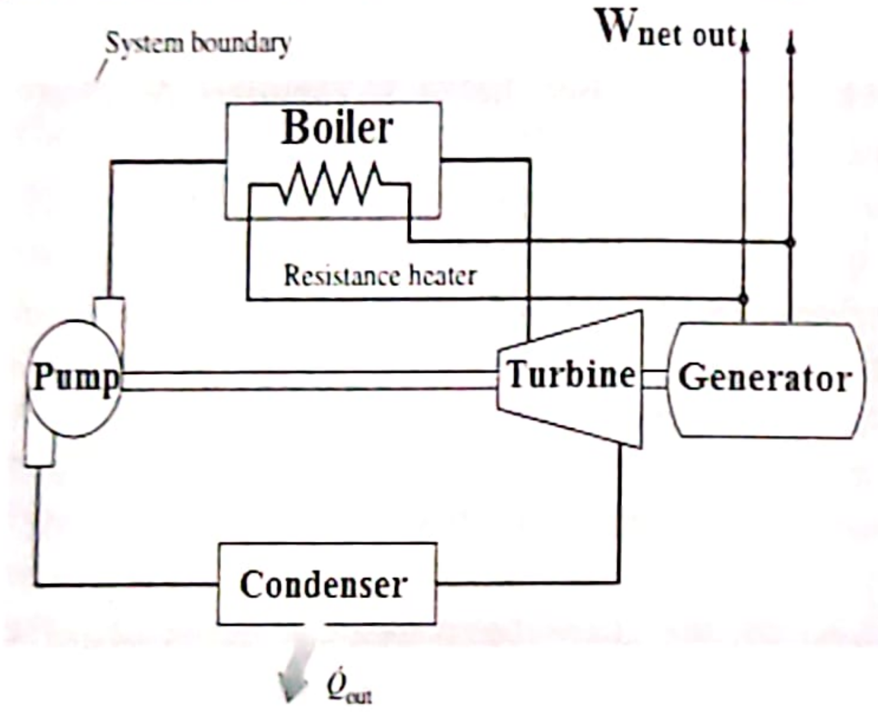


Fig.: PMM1

একটা steam power plant এর কথা চিন্তা করা যাক যেখানে boiler এর ভিতর একটা resistance heater এর মাধ্যমে পানিতে তাপ দিয়ে steam তৈরি করা হচ্ছে। আর যে পরিমাণ বিদ্যুৎ তৈরি করা হচ্ছে তার একটা অংশ বয়লার ফিড পাম্পে আর হিটারে ব্যবহার করা হচ্ছে। আর বাকি electric energy কে net work output হিসাবে electric network এ দেওয়া হচ্ছে। আবিষ্কারক দাবী করলেন এই প্ল্যান্টটা একবার চালু হলে কোন প্রকার বাহ্যিক শক্তি (কয়লা/নিউক্লিয়ার) ছাড়াই অনবরত বিদ্যুৎ উৎপাদন করতে থাকবে। আচ্ছা, এই রকম আবিষ্কার পেলে অবশ্যই বিশ্বের শক্তির যোগানের কোন ভাবনা হত না। কিন্তু thermodynamics first law অনুসারে এটা কখনোই সম্ভব নয়। Therefore, this wonderful device is nothing more than a PMM1 and does not warrant any further consideration.

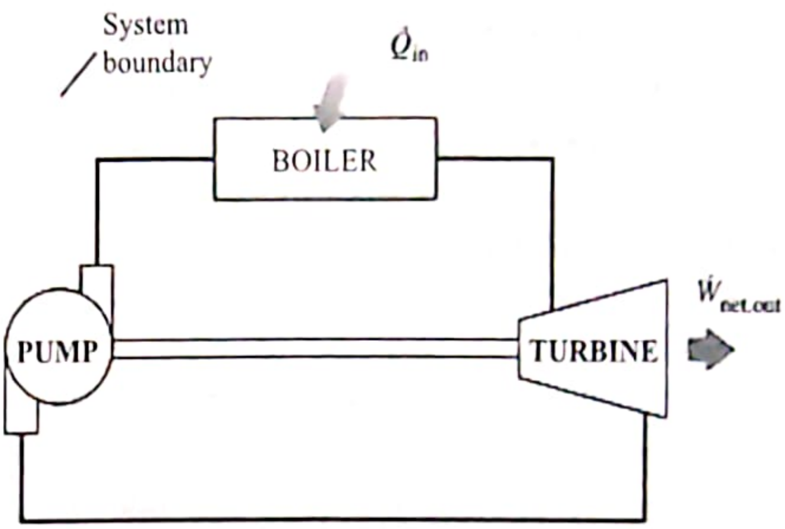


Fig.: PMM2

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Properties – 2 types (i) intensive and (ii) Extensive

(i) **Intensive Properties**: Intensive properties are those that are independent of size (mass) such as T, P, age, color or any mass independent property.

(ii) **Extensive Properties**: Extensive properties are those that vary directly with the extent of the system. These properties depend on the mass of the system. Some extensive properties- mass, volume, total energy or any mass dependent property.

18. Thermodynamic process কি?

When a system changes its state from one equilibrium state to another equilibrium state then the path of successive states through which the system has passed, is known as a thermodynamic process.

All thermodynamic process are classified into the following two groups-

(i) Non-flow processes

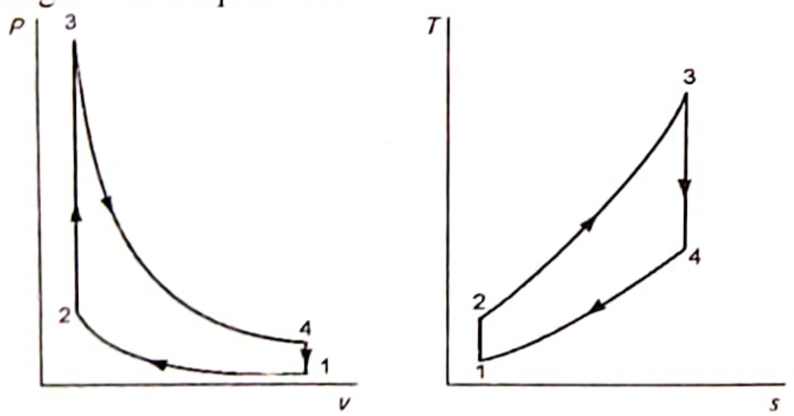
(ii) Flow processes

Non-flow process is classified into four classes.

a) Constant volume process (or Isochoric process)
b) Constant pressure process (or Isobaric process)
c) Constant temperature process (or Isothermal process)
d) Adiabatic Process (or Isentropic process)

19. Draw P-V and T-S diagram of Otto cycle, diesel cycle, Stirling cycle, dual cycle and Joule cycle.

Otto Cycle: Otto cycle consists of two isentropic and two isochoric processes. Heat is supplied and heat is rejected by the cycle during isochoric process.

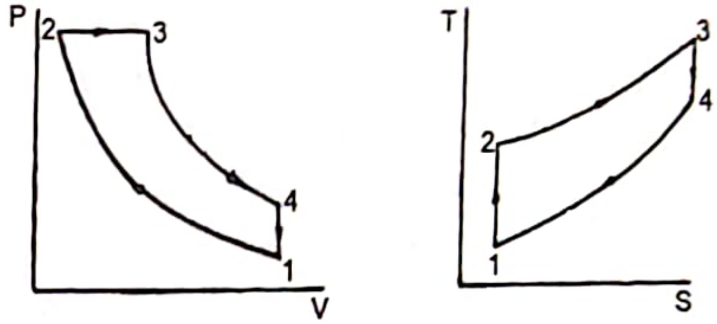


Pressure-volume and Temperature-entropy diagram for the air-standard Otto cycle

Where,
1-2: Adiabatic compression
2-3: Isochoric/constant volume heat addition
3-4: Adiabatic expansion
4-1: Isochoric heat rejection

Diesel Cycle:

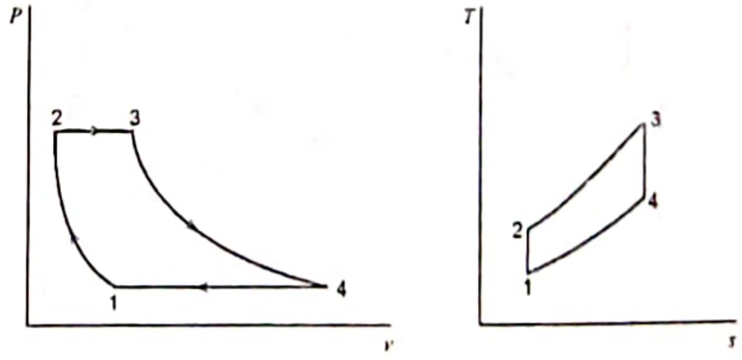
This is the ideal cycle for the diesel engine, which is also called the compression ignition engine. This cycle consists of two reversible adiabatic, one reversible isobaric and one reversible isochoric process.



Pressure-volume and Temperature-entropy diagram for the air-standard Diesel cycle

Basic processes in diesel cycle
1-2: Reversible adiabatic compression
2-3: Constant pressure heat addition
3-4: Reversible adiabatic expansion
4-1: Constant volume heat rejection

Brayton Cycle/Joule Cycle: The air-standard Brayton cycle is a theoretical cycle for gas turbines.

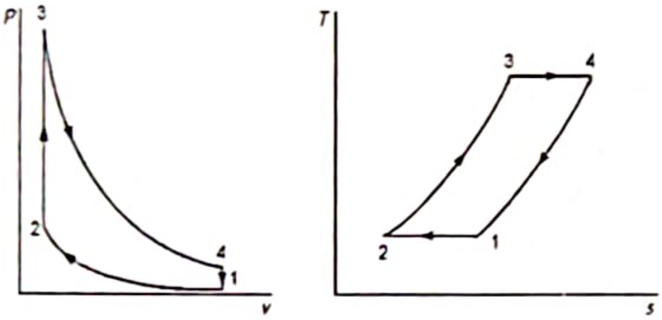


P-V and T-S diagram for the air-standard Brayton cycle

Where,
1-2: Isentropic process
2-3: Isobaric process
3-4: Isentropic Process
4-1: Isobaric process

Stirling cycle:

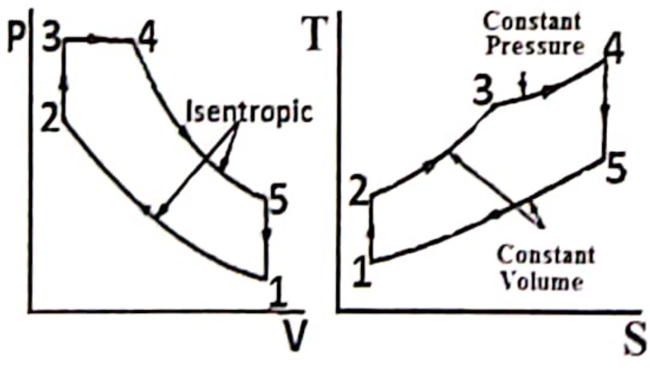
Stirling cycle consists of two isothermal and two isochoric processes. Heat rejection and heat addition takes place at constant temperature.



Where,
1-2: Isothermal compression
2-3: Constant volume heating
3-4: Isothermal expansion
4-1: Constant volume cooling

Dual Combustion Cycle:

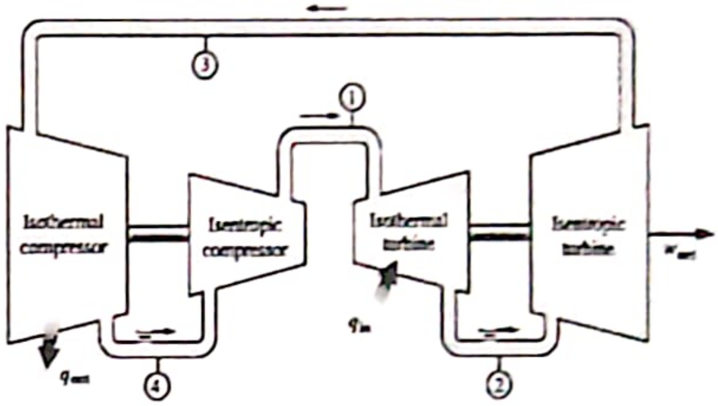
This cycle is a combination of Otto and Diesel cycles. It is sometimes called semi-diesel cycle. In this cycle, heat is absorbed partly at a constant volume and partly at a constant pressure.

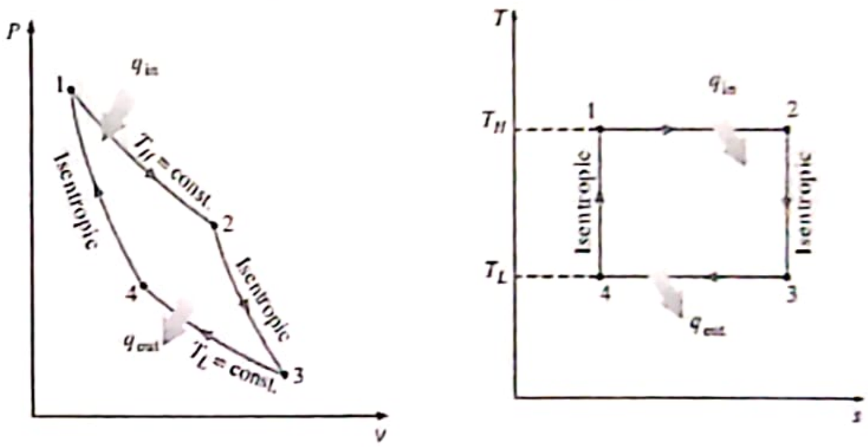


Where,
1-2: Reversible adiabatic or isentropic compression
2-3: Constant volume heating

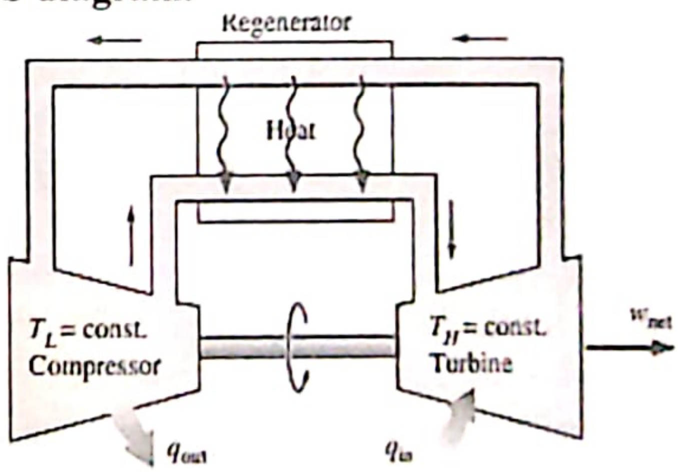
3-4: Constant pressure heating
4-5: Reversible adiabatic or isentropic expansion
5-1: Constant volume heat rejection.

20. Draw the schematic diagram of Carnot cycle with P-V and T-S diagram.

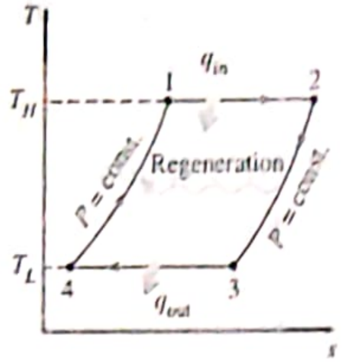




21. Draw the schematic diagram of Ericsson cycle with P-V and T-S diagram.







22. Define dew-point temperature.

Answer: The dew-point temperature T_{dp} is defined as the temperature at which condensation begins when the air is cooled at constant pressure. In other words, T_{dp} is the saturation temperature of water corresponding to the vapor pressure.

23. Saturated air কাকে বলে?

Answer: By definition, dry air contains no water vapor, and thus its specific humidity is zero. Now let us add some water vapor to this dry air. The specific humidity will increase. As more vapor or moisture is added, the specific humidity will keep increasing until the air can hold no more moisture. At this point, the air is said to be saturated with moisture, and it is called saturated air.

24. Evaporative Cooling এর concept ব্যাখ্যা করো।

Answer: Conventional cooling systems operate on a refrigeration cycle, and they can be used in any part of the world. But they have a high initial and operating cost. In desert (hot and dry) climates, we can avoid the high cost of cooling by using evaporative coolers, also known as swamp coolers. Evaporative cooling is based on a simple principle: As water evaporates, the latent heat of vaporization is absorbed from the water body and the surrounding air. As a result, both the water and the air are cooled during the process. This approach has been used for thousands of years to cool water. A porous jug or pitcher (usually in the villages it is often seen the clay pitcher of similar concept) filled with water is left in an open, shaded area. A small amount of water leaks out through the porous

holes, and the pitcher 'sweats.' In a dry environment, this water evaporates and cools the remaining water in the pitcher.

25. Define homogeneous materials and isotropic materials; give an example each of them.

Answer:

Homogeneous: A homogeneous material means a material which has uniform composition and uniform properties throughout. Plastics, ceramics, glass, metals, alloys, paper, board, resins, and coatings are examples of homogeneous materials. Air, salt solution, etc are examples of homogeneous mixtures. In addition, an alloy is a solid solution, which is a homogeneous solid mixture of two metals.

Isotropic: Isotropic means that the properties of materials are the same in all directions. In processes, the rate of process is the same in all directions. Glass and metals are examples of isotropic materials

26. What are CFC, HCFC and HFC? Give example of them with the effect on environmental pollution.

Answer:

CFC (chlorofluorocarbons): They are molecules composed of carbon, chlorine and fluorine. They are stable, allowing them to reach the stratosphere without too many problems. At this stage, by transforming it contributes to the destruction of the ozone layer.

HCFC (hydro chlorofluorocarbon): They are molecules composed of carbon, chlorine, fluorine and hydrogen. They are less stable than CFCs destroy ozone and to a lesser extent. These are called transitional substances.

HFC (hydro fluorocarbons): They are molecules composed of carbon, fluorine and hydrogen. They do not contain chlorine and therefore do not participate in the destruction of the ozone layer. This is known as substitution substance. Restrictions on this family of gas are currently limited.

27. Write the difference between pump, compressor, blower and fan.

Answer:

Pump: A device which converts mechanical energy from a shaft into hydraulic (pressure) energy of a liquid. A pump is a

device used to move fluids, such as liquids or slurries. A pump displaces a volume by physical or mechanical action. Pumps fall into two major groups: positive displacement pumps and roto dynamic pumps. For example, reciprocating pumps and gear pumps are positive displacement pumps whereas centrifugal pumps and submersible pumps are roto dynamic pumps.

Fan: A fan is a gas pump with relatively low pressure rise and high flow rate. Examples: window fans, ceiling fans, fans in computers and other electronics equipment, radiator fans in cars, etc.

Pressure Ratio (the ratio of the discharge pressure over the suction pressure): upto 1.11.

Blowers: A blower is a gas pump with relatively moderate to high pressure rise and moderate to high flow rate.

Examples: leaf blowers, hair dryers, air blowers in furnaces and automobile ventilation systems.

Pressure ratio: 1.11 to 1.20.

Compressor: A compressor is a gas pump designed to deliver a very high pressure rise, typically at low to moderate flow rates.

Examples: tire pumps, refrigerator and air conditioner compressors.

Pressure Ratio: Above 1.20.

28. What are the differences between Boiling Point and Melting Point.

Answer:

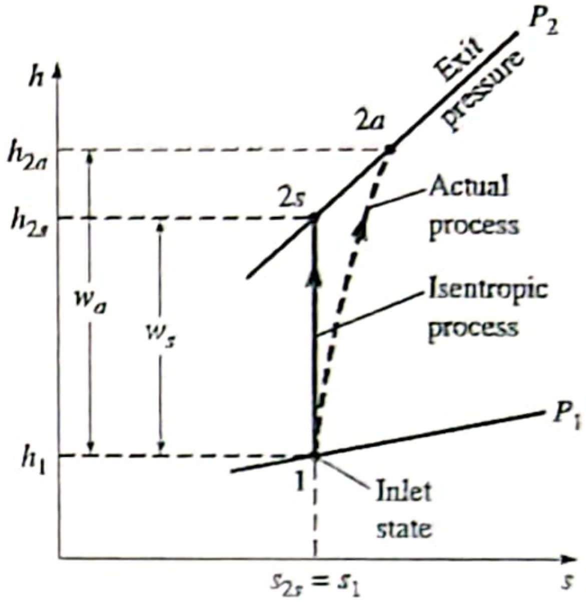
a. The melting point is defined for solids when it transfers from solid state to liquid state.
b. The boiling point is defined for liquids for a state change from liquid to gas.
c. Boiling point is highly dependent on the external pressure whereas the melting point is independent of the external pressure.

29. What is isentropic efficiency? Show the equation of isentropic efficiency of a compressor in terms of enthalpy with necessary diagram.

Solution: Isentropic efficiency is a parameter to measure the degree of degradation of energy in steady-flow devices. It involves a comparison between the actual performance of a

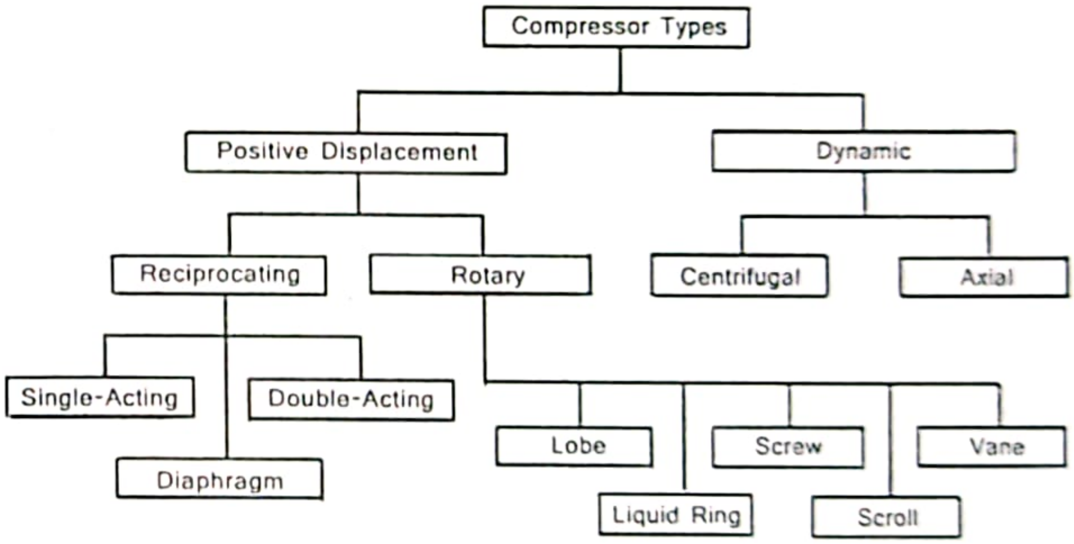
device and the performance that would be achieved under idealized circumstances for the same inlet and exit states.

$$\eta_c = \frac{\text{Isentropic compressor work}}{\text{Actual compressor work}} = \frac{W_s}{W_a} = \frac{h_{2s} - h_1}{h_{2a} - h_1}$$



30. Classify Air Compressor.

Answer: Types of Air compressor:



Description of some Air compressor:

Reciprocating In-line Compressors: These are most commonly used compressors with varying pressure ranges. These are simple in design with almost very little automation. The cylinders of various stages are found in a straight line when seen from top. These compressors are commonly direct driven by electric motors or diesel engines.

'V'-Shaped Compressors: These are usually air cooled compressors with concentric valves mounted on each cylinder

head unit. The compressor has different units displaced usually by 90 degrees, may or may not be connected to same crank pin on the crank shaft. Higher capacity compressors are water cooled.

Single-Acting Compressors: These are usually reciprocating compressors, which has piston working on air only in one direction. The other end of the piston is often free or open which does not perform any work. The air is compressed only on the top part of the piston. The bottom of the piston is open to crankcase and not utilized for the compression of air.

Double-Acting Compressors: These compressors are having two sets of suction/intake and delivery valves on both sides of the piston. As the piston moves up and down, both sides of the piston is utilized in compressing the air. The intake and delivery valves operate corresponding to the stroke of the compressor. The compressed air delivery is comparatively continuous when compared to a single-acting air compressor. Thus both sides of the pistons are effectively used in compressing the air.

Rotary Compressors: These compressors are not of reciprocating nature, therefore does not have any pistons and crankshaft. Instead, these compressors have screws, vanes, scrolls, and other devices which rotate and thus compress air.

31. What is steam trap? What are the types of steam trap? Describe the using of steam Trap.

Answer: Steam trap: Steam traps are a type of automatic valve that filters out condensate and non-condensable gases such as air without letting steam escape. Generally used in steam lines, they drain the condensate without affecting the steam. This helps in drawing all the energy from steam and thus utilizing its latent heat as the steam is contained in the heating line until it is fully condensed.

Types of Steam trap:

1. Mechanical Steam Traps
2. Thermodynamic Steam Traps

3. Thermostatic Steam Traps

Using steam trap in process industry: In industry, steam is used regularly for heating or as a driving force for mechanical power. Most steam traps are nothing more than automatic valves which prevents the passage of steam but allows the condensate to flow through. Generally used in steam lines, they drain the condensate without affecting the steam.

They open, close or modulate automatically very well.

32. What are the applications of air compressor?

Answer: সকল ধরনের ইন্ডাস্ট্রিতে air compressor ব্যবহৃত হয়। যেসব ক্ষেত্রে অটোমেশন আছে সেসব ইন্ডাস্ট্রিতে pneumatic equipment গুলোর জন্য air compressor ব্যবহৃত হয়। ফুড ইন্ডাস্ট্রি, গার্মেন্টস, অটোমোবাইল, পাওয়ার প্ল্যান্ট সহ যত ধরনের ইন্ডাস্ট্রি আছে সবগুলোতেই কোন না কোন কাজে compressed air লাগে আর তাই air compressor থাকেই। শুধু তাই নয় মেডিক্যালে, ল্যাবরেটরিতে, যে কোন ধরনের ওয়ার্কশপে, এমনকি বর্তমানে মাছের হ্যাচারীগুলোতেও air compressor ব্যবহার করা হয়।

33. Name some manufacturing companies of air compressor.

Answer: আমার দেখা সবচেয়ে বেশি ব্যবহৃত air compressor -গুলো Ingersoll-Rand কোম্পানীর এবং কিছু সংখ্যক দেখেছি Atlas Copco- এর। এছাড়াও রয়েছেঃ GE, Siemens ইত্যাদি।

34. Why multistage compressors are mostly used than single stage compressor ?

Answer: More stages are needed to increase the required final pressure.

a) Easier to control the air temperature.

b) Reducing in air compressor size.

c) Lubrication problem does not exit.

d) Reduced the thermal stress.

e) Lower work done to compressing air.

f) Improve compressor efficiency

Higher Calorific value is 50-52 MJ/kg.	Higher Calorific value is 54-56 MJ/kg.	Higher Calorific value is 46-51 MJ/kg.

37. What is the calorific value of Diesel, Petrol, coal and Uranium?

Answer:

Diesel (MJ/kg)	Petrol (MJ/kg)	Coal (MJ/kg)	Uranium **(GJ/kg)**	Natural Gas (MJ/kg)
42-46	44-46	17-23	Uranium enriched to 3.5%, in LWR 3900 GJ/kg	42-55

38. Why inter cooler is used at multistage air compressor?

Answer: In a multi-stage compression system, the intercoolers serve two functions:

(i) To reduce the temperature of the gas at the inlet to the next stage. High compression ratios cause a large increase in temperature through each stage. If the temperature were not reduced between stages, the compressed gas would exceed the temperature limits of the compressor equipment, resulting in mechanical damage.

(ii) To allow the condensation and separation of any heavy gas components and water vapor in the gas stream. Gas routed through an intercooler partially condenses to liquid that is then separated out by gravity. This reduces the work load on the next stage because less gas remains to be compressed.

39. What are the differences between Pressure Relief Valve and Pressure Safety Valve?

Answer:

Pressure Relief Valve	Pressure Safety Valve
A relief valve is a device used to limit the pressure in a system within a specific set level.	A safety valve is a device designed to actuate automatically to realse excess pressure.

35. What are the advantages of inter cooling of air compressor ?

Answer: To avoid excessive temperature rise associated with higher compression ratios, and to approach isothermal compression.

i. Saving in power.

ii. Volumetric efficiency is increased.

iii. Reduced the volume of air delivered and also reduced the compressor size.

iv. It can reduce the air temperature.

v. Due to less temperature suction & delivery valves remain cleaner without being fouled with carbonized oil.

vi. It can avoid a danger of an explosion takes place in compressor cylinder.

vii. It allows good lubrication of the compressor piston.

viii. Moisture separation is easier through inter cooler drains.

ix. It also enables to deal with a greater weight of air for the same energy expended.

36. What are the differences between CNG, LNG and LPG?

Answer:

CNG	LNG	LPG
Compressed Natural Gas	Liquefied Natural Gas	Liquefied Petroleum Gas
Primary component in CNG is methane.	Primary component in LNG is methane.	Primary component in LPG is propane and Butane.
Stored at high pressure. (200-250bar)	Cryogenically liquefied. (-161°C and atmospheric pressure)	Liquified under pressure. (15°C and 1.7 to 7.5bar)

Anthracite- 36 MJ/kg- 90%+ carbon
Bituminous- 33 MJ/kg- 75~90% Carbon+little moisture content (4~6)%
Lignite/Brown Coal- 25 MJ/kg -- 40% moisture+60% coal
Peat- 23 MJ/kg- upto 30% water contents

CNG	LNG	LPG
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Answer:

Pressure Relief Valve	Pressure Safety Valve
A relief valve is a device used to limit the pressure in a system within a specific set level.	A safety valve is a device designed to actuate automatically to realse excess pressure.

The opening of a relief valve is directly proportional to the increase in the vessel pressure.	A safety valve opens almost immediately and fully in order to prevent overpressure condition.
A relief valve opens when the pressure reached the specific set pressure limit and it is usually operated by an operator.	The purpose of a safety valve is to protect people, property and environment. It is used to release excess pressure without operator assistance.
The setpoint of a relief valve is usually set at 10 percent above the working pressure limit.	The setpoint of a safety valve is usually set at 3 percent above the working pressure limit.
Relief valves are divided into pop-type, direct-operated, pilot-operated and internal relief valves.	Safety valves are divided into a wide range of types based on applications and performance in different areas.

40. What is pipe rating and schedule?

Answer: Rating: The pressure rating (also known as pressure class) is the maximum pressure a pipe, fitting or valve should be capable of withstanding at given temperature in normal conditions.

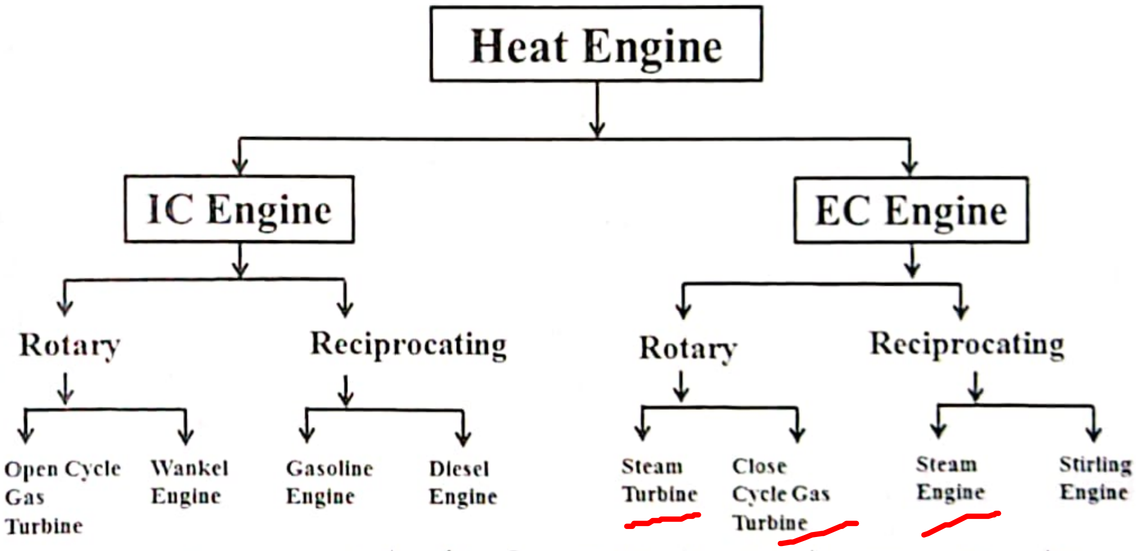
Schedule: Pipe Schedule is the term used to describe the thickness of a pipe. The outside diameter of a pipe is the same for all Schedules in a particular nominal pipe diamete

অধ্যায় ৩

IC Engine

1. Define an Engine.

Answer: An Engine is a device, which transforms the chemical energy of a fuel into thermal energy and uses this thermal energy to produce mechanical work. Engines normally convert thermal energy into mechanical work and therefore they are called heat engines.



অনেক সময় বলা হয়- গ্যাস টার্বাইন কি **IC Engine?** এই ধরনের প্রশ্নের উত্তরের সুবিধার্থে এই ছকটা কাজে লাগবে আশা করি।

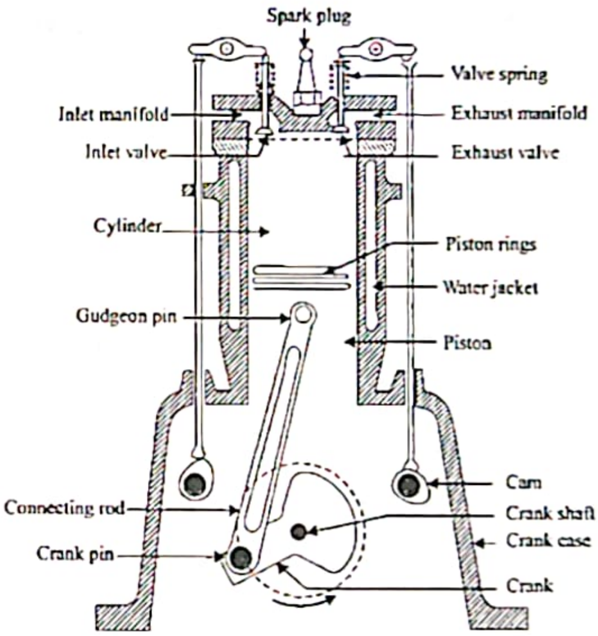
2. IC Engine এর কিছু Application বলুন।

Answer: IC Engine is mainly used as 'prime movers'of a vehicle: car, bus, truck, locomotive, marine vessel, or airplane. Other applications include stationary saws, lawn mowers, bull-dozers, cranes, electric generators, etc.

having long life and sufficient resistance to rapid wear and tear to the first moving reciprocating parts.

Cylinder head: Generally, the cylinder head contains inlet and exist valves for admitting fresh charge and exhausting the burnt gases. In petrol engine, the cylinder head also contain a spark plug and in diesel engines, the cylinder head contains nozzle (i.e. fuel valve) for injecting the fuel into the cylinder.

Generally, the cylinder block and cylinder head are made from the same material. **A copper or asbestos gasket** is provided between the engine cylinder and cylinder head to make an air-tight joint.



Piston: It is considered as the heart of an IC engine, made of **aluminum alloys**, which are light in weight. They have good heat conducting property and greater strength at higher temperature.

Piston Rings: made of **special steel alloys** which retain elastic properties even at high temperature.

There are two sets of rings mounted in the circumferential grooves provided on the outer surface of the piston.

Upper rings- provide airtight seal to prevent leakage of the burnt gases into the lower portion.

Lower rings- provide effective seal to prevent leakage of the oil into the engine cylinder.

3. IC Engine কত প্রকার?

Answer: ভাইভায় এই প্রশ্নের উত্তরে সবার আগে নিচের দুইটা প্রকারভেদ বলা দরকার আর যদি 'কিসের' ভিত্তিতে প্রকারভেদ বলে দেওয়া হয় তাহলে সেটায় বলতে হবে।

a. According to the cycle of operation:

i) Two stroke cycle engine ii) Four stroke cycle engine

b. According to the method of ignition:

i) Spark ignition (SI) engine ii) Compression ignition (CI) engine

4. Main components of an IC engine?

Answer: এই component গুলোতে চাকুরী পরীক্ষার যে বিষয়গুলোর উপর জানতে চাওয়া হয় তা হলো এগুলোর function, কি material দিয়ে তৈরি, temperature, pressure কত থাকে, কি ধরনের stress develop করে ইত্যাদি।

Cylinder block: (for multicylinder engine) এটা ইঞ্জিনের বিভিন্ন component এর supporting structure. বিশেষ করে Multi-cylinder engine এর cylinder কে একটা single unit হিসাবে casting করা হয়। এই single unit -কেই Cylinder block বলে। Cylinder block এর উপরে বসে Cylinder head. Water cooling engine এর ক্ষেত্রে Cylinder head এবং cylinder block এর মধ্যে অসংখ্য water jacket বা water cooling line থাকে এবং air cooling engine এর ক্ষেত্রে cooling fin থাকে। Cylinder head এবং cylinder block এর মাঝে একটা Gasket থাকে। The Cylinder head is held tight to the cylinder block by number of bolts or studs. The bottom portion of the cylinder block is called crankcase. A cover called crankcase which becomes a sump for lubricating oil is fastened to the bottom of the crankcase.

Cylinder: Pressure - more than 50 bar

(Temperature- more than 2000°C).

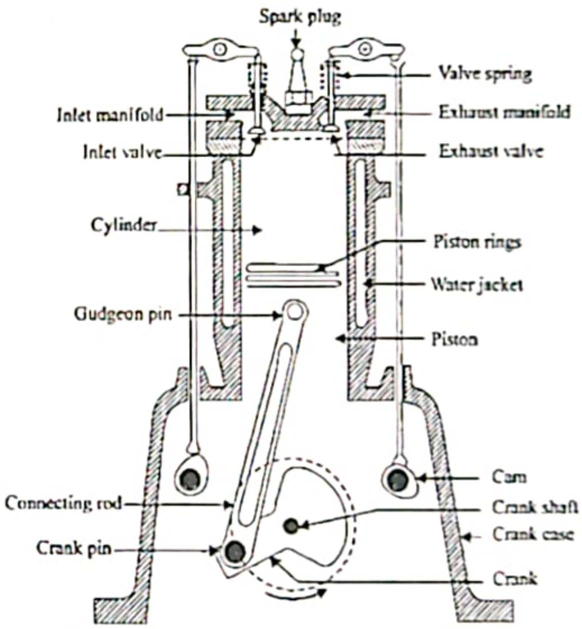
For ordinary engines, the cylinder is made of **ordinary cast iron**. For heavy duty engines, it is made of **steel alloys or aluminium alloys.**

Sometimes, linear or sleeve is inserted into the cylinder, which can be replaced when worn out. As the material required for liner is comparatively small, it can be made of alloy cast iron

having long life and sufficient resistance to rapid wear and tear to the first moving reciprocating parts.

Cylinder head: Generally, the cylinder head contains inlet and exist valves for admitting fresh charge and exhausting the burnt gases. In petrol engine, the cylinder head also contain a spark plug and in diesel engines, the cylinder head contains nozzle (i.e. fuel valve) for injecting the fuel into the cylinder.

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There are two sets of rings mounted in the circumferential grooves provided on the outer surface of the piston.

Upper rings- provide airtight seal to prevent leakage of the burnt gases into the lower portion.

Lower rings- provide effective seal to prevent leakage of the oil into the engine cylinder.

Connecting rod: It is a link between the piston and crankshaft, whose main function is to transmit force from the piston to the crankshaft. Moreover, it converts reciprocating motion of the piston into circular motion of the crankshaft, in the working stroke.

- made of **steel alloys or aluminum alloys**
- it is subjected to **alternatively compressive and tensile stresses as well as bending stresses.**

Crankshaft is the backbone of an I.C engine whose function is to convert reciprocating motion of the piston into the rotary motion with the help of connecting rod.

Special steel alloys are used for the manufacture of crankshaft.

Crank case: It is a **cast iron** case, which holds the cylinder and crankshaft of an I.C engine. It also serves as a sump for the lubricating oil. The lower portion of the crankcase is known as bed plate, which is fixed with the help of bolts.

Fly wheel: It is a big wheel, mounted on the crankshaft, whose function is to maintain its speed constant. It is done by storing excess energy during the power stroke, which is returned during remaining strokes.

5. What is two stroke Engine?

Answer: A Two-stroke engine is an internal combustion engine in which the piston's two strokes are required to complete single thermodynamic cycle.

6. What is four stroke Engine?

Answer: A four-stroke engine is an internal combustion engine in which the piston's four separate strokes are required to complete single thermodynamic cycle. Four separate strokes are - intake, compression, expansion or power, and exhaust, during two separate revolutions of the engine's crankshaft, and one single thermodynamic cycle. Each stroke consists of 180^{o} of crankshaft rotation and hence a four-stroke cycle is completed through 720^{o} of crank rotation.

7. Define octane number and cetane number? And mention the measure of rating of SI and CI engine?

Answer: Octane Number: Octane number is defined as the percentage, by volume, of iso-octane in the mixture of iso-octane and h-heptane. It is the measure of rating of SI engine.

Cetane Number: Cetane number is defined as the percentage, by volume, of n-cetane in the mixture of n-cetane and alpha methyl naphthalene. It is the measure of rating of CI engine.

8. How it is possible to eliminate autoignition as well as knocking at SI engine? Or, Why Tetraethyl lead (TEL) is added with gasoline?

Answer: Autoignition in spark-ignition engines cannot be tolerated because it hurts performance and can cause engine damage. The requirement that autoignition cannot be allowed places an upper limit on the compression ratios that can be used in spark ignition internal combustion engines.

Improvement of the thermal efficiency of gasoline engines by utilizing higher compression ratios (up to about 12) without facing the autoignition problem has been made possible by using gasoline blends that have good antiknock characteristics, such as gasoline mixed with tetraethyl lead. Tetraethyl lead had been added to gasoline because it is an inexpensive method of raising the octane rating, which is a measure of the engine knock resistance of a fuel.

9. Petrol engine এবং Gas engine কোন cycle -এ চলে?

Answer: Otto cycle.

10. Diesel Engine এ কয়টি valve থাকে?

Answer: Three valves- inlet valve, exhaust valve and injection valve.

১১. ডিজেল ইঞ্জিনে কিভাবে স্পার্ক প্লাগ ছাড়া কম্বাশন শুরু হয়?

Answer: In CI engines (also known as diesel engines), the air is compressed to a temperature that is above the auto ignition temperature of the fuel, and combustion starts on contact as the fuel is injected into this hot air. Therefore, the spark plug and carburetor are replaced by a fuel injector in diesel engines.

12. How knocking is prevented in SI and CI engine?

Answer: The knocking in the SI engine can be prevented if the end mixure (the charge away from the spark plug) is having: আমি মনে রাখার জন্য বলি 'four L.'

a) Low density
b) Low temperature
c) Long ignition delay and
d) Lean or rich mixure

The knocking in the CI engine can be prevented if the first element of the fuel is having:

a) High density
b) High temperature
c) A short ignition delay and
d) Reactive mixure (Low viscosity, high volatility etc.)

13. During idling process, a petrol engine requires lean or rich mixture?

Answer: Lean mixture. Rich Mixture

14. Why is multi-cylinder needed in one engine? Why not one big cylinder of the same displacement of the multi cylinders instead?

Answer: The main reason is smoothness. A multicylinder engine is much smoother because it has many (may have 8 cylinders or 16 cylinders etc.) evenly spaced explosions instead of one big explosion. Another reason is starting torque. When you start a multicylinder engine, you are driving a small volume of segmented cylinders through their compression strokes, but with one big cylinder, you would have to compress a large volume instead.

15. Diesel engine এবং Petrol engine এর মধ্যে কার efficiency বেশি? যদি উভয়ের জন্য compression ratio একই হয় তাহলে কার efficiency বেশি হবে?

Answer: The compression ratio of diesel engine (from 16 to 24) is much higher than that of petrol engine (from 8 to 12). Therefore, efficiency of diesel engine is higher due to its higher compression ratio.

$\eta_{Otto} = 1 - \frac{1}{(r)^{\gamma-1}}$	$\eta_{disel} = 1 - \frac{1}{r^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\gamma(\rho-1)}\right]$

The cut-off ratio ρ of the diesel engine is usually greater than 1 and γ is 1.4 for air, so the expression in square bracket is always greater than 1. Therefore, for the **same compression ratio,** petrol engine is more efficient than the diesel engine.

16. Why supercharger/turbocharger is used at petrol engine/diesel engine?

Answer: Supercharger বা Turbocharger মূলত ইঞ্জিনের combustion chamber এ extra **compressed** air সরবরাহ করার জন্য ব্যবহার করা হয়। দুইটা device-ই আসলে একটা compressor এর মাধ্যমে air compressed করে। The key difference between a turbocharger and a conventional supercharger is that a supercharger is mechanically driven by the engine, often through a belt/chain connected to the crankshaft, whereas a turbocharger is powered by a turbine and the turbine is driven by the engine's exhaust gas.

Thus, these forced induction devices are used to increase an internal combustion engine's efficiency and power output by forcing extra compressed air into the combustion chamber.

17. What is the rpm range of a turbocharger?

Answer: Turbo charger rpm depends on the engine output. Some nearest value of rpm are given below according to engine power.

Turbocharger rpm	Engine Power	Engine Manufacturer
26,500	7.0MW	Rolls Royce
1,00,000	1.5MW	Cater pillar
25,000	11.4MW	Wartsila
20,000	17.0MW	Wartsila
23,000	7.0MW	STX Niigata

18. What are the functions of lubrication?

Answer: (a) Reducing friction effect: Lubricant reduces friction between moving part.

(b) Produce cooling effect: The heat, generated by piston, cylinder, and bearings is removed by lubrication largely. Lubrication creates cooling effect on the engine parts.

(c) Produce sealing effect: The lubricant enters into the gap between the cylinder liner, piston and piston rings. Thus, it prevents leakage of gases from the engine cylinder.

(d) Produce cleaning effect: Lubrication keeps the engine clean by removing dirt or carbon from inside of the engine along with the oil

(e) It helps reduce noise created by the moving parts.

19. Classify lubricants.

Answer: Following are the commonly known types.

1. Liquid Lubricants

a) Plain mineral oil

b) Mineral oil plus additive

c) Synthetic lubricants

2. Quasi-solid Lubricants (Grease)

3. Solid Lubricants (Graphite)

20. Which engine parts are lubricated?

Answer: a. Crankshaft b. Crank pin c. Big and small end of the connecting rode d. Piston pin e. Internal surfaces of cylinder walls f. Piston rings g. Valve mechanisms h. Camshaft etc.

21. Engine lube oil classification.

Answer: Service classifications are determined by the American Petroleum Institute (API), while oil viscosity grades are determined by the Society of Automotive Engineers (SAE).



The API service symbol "Donut" is divided into three parts:

1- The top half describes the oil's performance level (for gasoline and/or diesel engines).

2- The center identifies the oil's viscosity.

3- The bottom half tells whether the oil has demonstrated energy-conserving

	properties in a standard test in comparison to a reference oil, or if an oil meets CI-4 PLUS requirements.

This resulted in 11 distinct motor oil viscosity classifications: 6 low-temperature grades (0W, 5W, 10W, 15W, 20W, and 25W) and 5 high-temperature grades (SAE 20, 30, 40, 50, and 60).

The API system has two general categories: 'S' categories and 'C' categories.



The 'S' (Service / Spark ignition) classifications are for oils designed for gasoline-engine service (cars, vans, and light trucks with gasoline-engines).

SL (for 2004 and older gasoline-engines), SM (for 2010 and older gasoline-engines) and SN (for modern gasoline-engines) are the currently recognized API classes; previous classifications are obsolete.

The 'C' (Commercial / Compression Ignition) classifications are for oils designed for diesel-engine commercial service (heavy-duty trucks and other vehicles with diesel engines).

They include CA, CB, CC, CD, CD-II, CE, CF, CF-2, CF-4, CG-4, CH-4, CI-4, CI-4 PLUS and CJ-4.

API service category for gasoline engines: SG is for oils that meet warranty requirements effective with the 1989 model year.

CF/CD/CE

CD means the oil is suitable for certain naturally aspirated, turbocharged or supercharged engines.

CE means the oil is suitable for certain heavy duty turbocharged or supercharged engines.

CF means the oil is for use in high speed, four stroke cycle engines.

SAE Viscosity ratings- This rating reflects the oil's ability to flow at various temperature.

Multi-grade oil (5W-30)- The W means it will perform well in winter conditions. The lower the first number ("5"), the better the ability to flow in extremely cold weather and the easier the engine will crank and start.

The second number ('30') in a multi-grade rating indicates the suitability for hot-weather service. The higher the number, the hotter the weather it can handle.

Energy Conserving oils reduce power losses from internal friction. This means that more power gets through to the drive wheels, resulting in better fuel mileage.

22. What do you mean by lube oil grade ISO VG 32?

Answer: For Gas turbine, Steam turbine, Boiler feed pump, compressor and such other types of equipment most of the times use the lube oil of grade ISO VG 32 or ISO VG 46.

It will be better to know the background history briefly of ISO VG type lubricants. In 1975, the International Standardization Organization (ISO), in unison with American Society for Testing and Materials (ASTM), Society for Tribologists and Lubrication Engineers (STLE), British Standards Institute (BSI), and Deutsches Institute for Normung (DIN) settled upon an approach to minimize the confusion. It is known as the International Standards Organization Viscosity Grade, ISO VG for short.

Thus ISO VG 32 describes that the lubricant has a midpoint viscosity of 32cSt (centistroke) and kinematic viscosity limits 28.8cSt to 35.2cSt at 40°C.

23. Type of engine lubrication system?

Answer: There are three common systems of lubrication used on stationary engines, tractor engines and automobiles:

(i) Splash system: In this system, there is an oil trough, provided below the connecting rod. Oil is maintained at a uniform level in the oil trough. This is obtained by maintaining a continuous flow of oil from the oil sump or reservoir into a

splash pan, which has a depression or a trough like arrangement under each connecting rod.

(ii) Forced feed system: In this system, the oil is pumped directly to the crankshaft, connecting rod, piston pin, timing gears and camshaft of the engine through suitable paths of oil.

(iii) Combination of splash and forced feed system: In this system, the engine component, which are subjected to very heavy load are lubricated under forced pressure, such as main bearing connecting rod bearing and camshaft bearing. The rest of the parts like cylinder liners, cams, tappets etc are lubricated by splashed oil.

24. What are the equipment needs for an engine lube oil system?

Answer: Oil pump, Oil filter, Oil pressure gauge, Crankcase breather, Relief valve etc.

25. Type of engine cooling system?

Answer: There are two types of cooling systems: (i) Air cooling system and (ii) Water-cooling system.

26. What are the parts of liquid cooling system?

Answer: The main parts in the water-cooling system are:

(i) water pump, (ii) fan, (iii) radiator and pressure cap, (iv) fan belt (v) water jacket, (vi) thermostat valve, (vii) temperature gauge and (viii) hose pipes.

27. What will happen if petrol is used at diesel engine?

Answer:

Engine type	Compression Ratio	Auto Ignition Temperature	Flash Point	Pressure and temperature at end of compression
Diesel Engine	17:1 to 24:1	210 °C	50°C that means low volatile	30-50bar & around 700 °C
Petrol Engine	8:1 to 12:1	280 °C	−43 °C that means high volatile	7-15bar & around 350 °C

এখন আমরা দেখি যে, একটা Petrol Engine সাধারণ অবস্থায় অর্থাৎ Petrol দ্বারা combustion হলে কেমন আচরণ করে। একটা Petrol Engine-এ যখন

carburetor এ air-fuel mixing হয় তখন এটি সহজেই Vapor/ charge তৈরি করে কারণ Petrol এর Flash point অনেক কম হওয়ায় এর Volatility বেশি এবং এটি compression stroke এর শেষে compression ratio (8:1) অর্জন করার পর compression ঘটায়। কিন্তু compression এর ফলে যে তাপমাত্রা তৈরি হয় তা পেট্রোলের Auto Ignition Temperature এর চেয়ে অনেক কম। তাই এই ক্ষেত্রে spark plug এর ব্যবহার করতে হয়। এখন আমরা দেখি পেট্রোল ইঞ্জিনে যদি ডিজেল ব্যবহার করা হয় তাহলে কি ঘটবে। পেট্রোল ইঞ্জিনে ডিজেল ব্যবহার করলেও সে carburetor এ যাবে এবং সেখানে air-fuel mixing হয়ে Vapor/ charge তৈরি করবে না কারণ Diesel এর Flash point অনেক বেশি হওয়ায় এর Volatility কম, charge তৈরি না হওয়ায় Diesel অনেক denser থাকে। এখন এই অবস্থায় যখন কম্প্রেশন হয় Diesel denser হওয়ায় ডিজেল তার নিজস্ব Auto Ignition Temperature এ পৌঁছাবে না তাছাড়া Petrol Engine-এর ডিজাইন অনুসারে compression ratio 8:1 এর বেশি হবে না যেখানে Diesel এর compression ratio 16:1. যেহেতু Diesel auto ignition temperature এ পৌঁছাবেই না সেহেতু সেখানে spark plug এ spark করলেও ignition হবে না। অর্থাৎ misfire হবে। অনেক সময় ইঞ্জিনে আগে থেকে কিছু petrol থাকার ফলে unburned combustion হয়। যার দরুন black smoke দেখা যায় এবং ইঞ্জিনে knocking হয়। Petrol Engine-এ Diesel ব্যবহারের ফলে fuel filter block হয়ে যায় এবং spark plug jam হয়ে যায়।

বি.দ্র.ঃ Petrol Engine-এ পারত-পক্ষে Auto Ignition না হওয়ায় কাম্য কারণ, যদি spark plug এ sparking এর আগেই Auto Ignition হয় তাহলে ব্যাপারটা দাঁড়ালো fuel-এর একটা অংশে combustion হলো আবার sparking এর পর একটা অংশে combustion হলো, combustion chamber-এর একাধিক জায়গায় combustion-এর ফলে Piston- এর Power stroke movement smooth হবে না । তাই নকিং হবে।

X

এখন, Diesel Engine-এ যদি Petrol ব্যবহার করা হয় তাহলে কি ঘটবে? - আমরা জানি Diesel Engine-এর compression ratio (16:1) অনেক বেশি এবং end of compression Diesel Engine-এ যে তাপমাত্রা তৈরি হয় তা Petrol এর Auto Ignition Temperature এর অনেক বেশি। অর্থাৎ injector এর মাধ্যমে যখন Petrol inject করা হয় তখন তা compression শেষ হওয়ার আগেই Auto Ignition Temperature অর্জন করে। আর তাই অনেক আগেই combustion শুরু হয়। ফলে মারাত্মক knocking হয় যা engine কে damge করে দিতে পারে।

28. What are OHV, SOHC and DOHC?

Answer: আমরা দেখেছি, single cylinder engine-এর ক্ষেত্রে camshaft দ্বারা push rod এর উঠানামার মাধ্যমে rocker arm এর সাহায্যে valve opening-closing করা হয়। কিন্তু multi-cylinder engine এর ক্ষেত্রে অনেকগুলো valve opening-closing এর জন্য এই arrangement টা একটু আলাদা হয়। যেমনঃ Variable Valve Timing (according to firing order). আর সেই সাপেক্ষে একাধিক rocker arm কে পরিচালিত করা। আর সেই জন্যই OHV (Over Head Valve), OHC or SOHC (Single Over Head Cam) and DOHC (Double Over Head Cam) এইগুলো ব্যবহার করা হয়।

OHV: OHV configurations use a centrally located cam shaft (central to the engine block), and actuates the valves through the use of lifters, pushrods, and rocker arms. The OHV configuration does away with most of this for the reduction of mass in the valve train. This reduction of mass usually means the engine can run safer and cleaner at higher engine speeds due to less inertial pressures on the valve train. Also, since this is more of a direct actuation of the valves, there is less flex (due to push rods) and a more accurate valve actuation occurs.

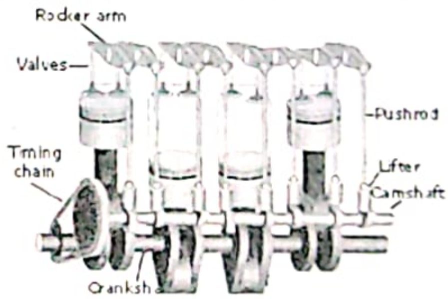


Fig.: Over Head Valve Arrangement

SOHC: SOHC stands for Single Overhead Cam (Only one cam rod operating the intake and exhaust valves). That means there is only one camshaft in the head. Inline engines will have one camshaft. Flat engine and V-engine will have two camshafts, one per cylinder bank.

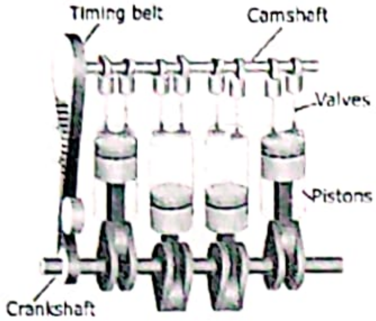


Fig.: Single Over Head Cam Arrangment

DOHC: DOHC means Double Over Head Cam. A DOHC engine design is often called Twin Cam or Dual Cam. The majority of modern cars have a DOHC engine. A typical DOHC engine has two camshafts and four valves per cylinder, like the one in this animation. One camshaft operates intake valves, while another camshaft controls exhaust valves on the opposite side.

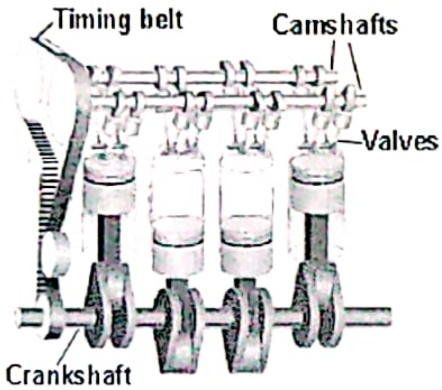


Fig.: Double Over Head Cam Arrangment

29. Why intake valve is larger than the exhaust valve?

Answer: The reason is that when the intake valve is open, the only force moving air-fuel mixture into the cylinder is atmospheric pressure (which is low).

30. What is stoichiometric air?

Answer: Stoichiometric (or chemically correct) mixture of air and fuel is one that contains just sufficient oxygen for complete combustion of the fuel. For a gasoline (petrol) engine, the stoichiometric air-fuel ratio is around 14.7:1. This means that, in order to burn completely 1 kg of fuel, we need 14.7 kg of air. A lean air/fuel mixture is when there is more air than

required to burn the fuel. A rich mixture is when there is too little air for the given quantity of fuel.

31. Which country mostly emits carbon?

Answer: China emits carbon mostly

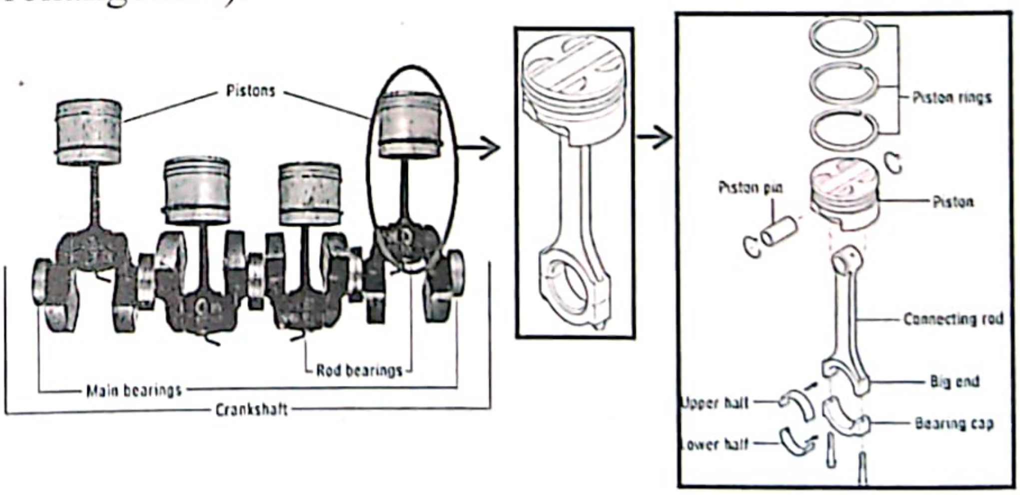
32. How does a flywheel work?

Answer: It can be compared to the mechanism of a mechanical battery. Whereas the battery stores the energy in a chemical form, a flywheel preserves the power in the form of movement or kinetic energy to be precise. A flywheel will be able to store more energy if it spins at a higher speed or has a higher moment of inertia, which means bulkier.

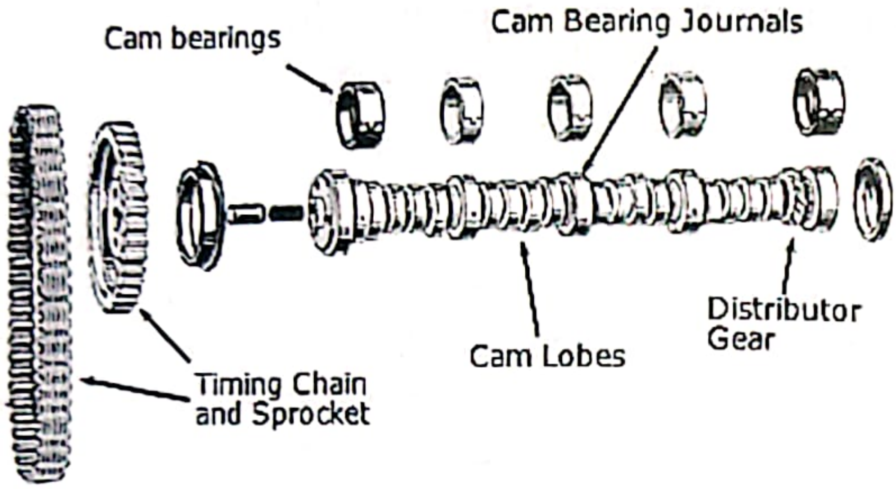
33. Engine bearing গুলো সম্পর্কে ধারণা নেওয়া যাক।

Answer: Main crankshaft bearing: Main crankshaft bearings support the crankshaft and help it to rotate under inertia forces generated by the parts of the shaft and oscillating forces transmitted by the connecting rods. Main bearings are mounted in the crankcase. A main bearing consists of two parts: upper and lower. The upper part of a main bearing commonly has an oil groove on the inner surface. A main bearing has a hole for passing oil to the feed holes in the crankshaft.

Connecting rod bearings/big end bearing: Big end bearing provides rotating motion of the crank pin within the connecting rod, which transmits cycling loads applied to the piston. Connecting rod bearings are mounted in the Big end of the connecting rod. A bearing consists of two parts (commonly interchangeable).



Camshaft bearings: Camshaft bearings support camshaft and provide its rotation.



34. Dynamometer কেন ব্যবহার করা হয়?

Answer: The brake power measurement involves the determination of the torque and the angular speed of the engine output shaft. The torque measuring device is called a dynamometer.

Dynamometers can be broadly classified into two main types,

(i) Power absorption dynamometers- prony brake, rope brake, hydraulic dynamometer, etc

(ii) Transmission dynamometer or torque meter.

35. Define a carburetor.

Answer: The carburetor works on Bernoulli's principle. A carburetor has been defined as a mechanical device to produced mixture of fuel and air in accordance with the requirements of the S.I engine.

Parts of a Simple Carburetor:

Float Chamber: The main function of the float chamber assembly is to maintain the fuel level constant in the float chamber under variables loads on engine.

Venturi: The fuel flows through the fuel nozzle and mixes with the air as the air flows through the venturi.

Throttle valve: The basic control element is the throttle valve. It controls the velocity of the mixture supplied to the engine through the intake manifold and therefore the head under which the fuel flows.

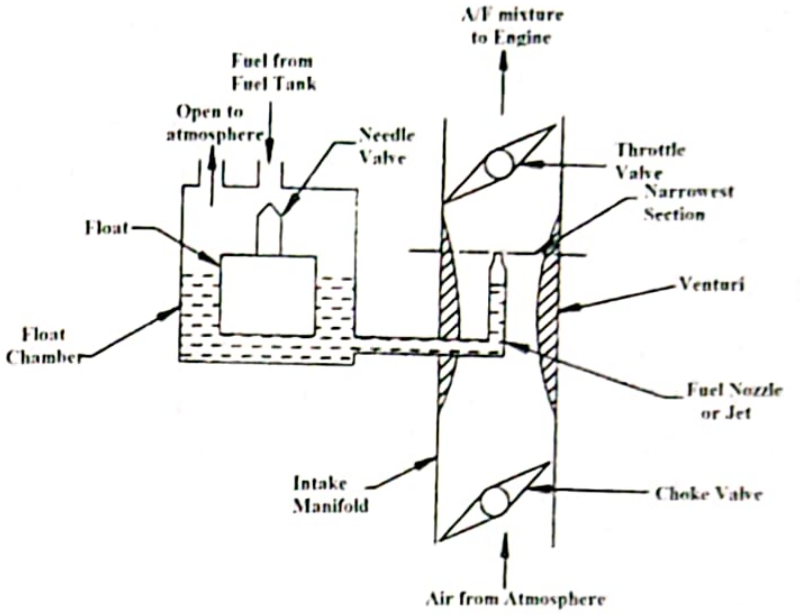


Fig.: Fuel Carburation System

Choke valve: It is necessary to provide an extra rich mixture to the engine during starting or warm up in cold weather. The extra rich mixture ensures enough fuel availability in vaporized from for combustion. This is done by introducing the chock valve in the air passage before the venturi.

36. Working principle of a simple carburetor

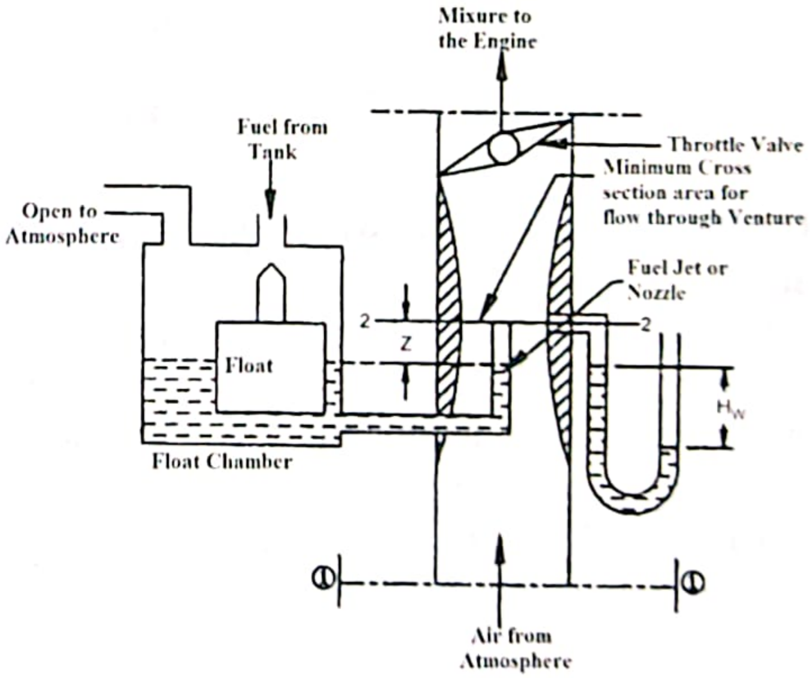


Fig.: Working Principle of a Fuel Carburation System

The main function of the carburator is to vaporize the petrol by means of engine suction and to supply the required quantity of

the mixture (air and petrol) in proper proportion. As the engine is started, the suction is created inside the cylinder and air flows atmosphere into the cylinder. As the air passes through the venturi, the pressure of the air falls bellows the atmosphere and that is equivalent to h_w, cm of water. The pressure of the nozzle tip is also h_w, cm of water below, atmosphere because the pressure on the fuel surface in the fuel tank is also atmospheric. This pressure difference causes the flow of the fuel through the fuel jet into the air stream. As the fuel and air pass ahead of the venturi, the fuel gets vaporized and uniform mixture is supplied to the engine. The quality of the mixture supplied to the engine depends upon the opening of the throttle valve. In case of stationary engine, the opening of the throttle valve is controlled by the governor according to the load on the engine, in case of automobile engine on road; the opening of the throttle valve is controlled by the driver through the accelerator pedal.

37. What are the causes of surface ignition?

Answer: Surface ignition

- occurs due to local hotspot, because of dust particle of combustion chamber.
- occurs when lubrication oil is not changed for a long period of time.

38. What will happen if ice water is supply for engine cooling?

Answer: It is necessary to maintain a minimum temperature difference between the jacket water inlet and outlet temperature. If the inlet temperature is too much low the thermal crack will be occurred.

39. Why anti freeze is used at engine radiator?

Answer: In western countries if the water used in the radiator freezes because of cold climates, then ice formed has more volume and produces cracks in the cylinder blocks, pipes, and radiator. So, to prevent freezing antifreeze mixtures or solutions are added in the cooling water.

Normally following are used as antifreeze solutions:

(i) Methyl, ethyl and isopropyl alcohols
(ii) A solution of alcohol and water
(iii) Ethylene Glycol raises the boiling temperature substantially and hence more heat dissipation
(iv) A solution of water and Ethylene Glycol
(v) Glycerin along with water, etc.
(vi) Chromates are used to prevents deposit

40. What are the effect of overcooling?

Answer:

-Thermal efficiency is decreased due to more loss of heat carried by the coolant

-The vaporization of the fuel is less resulting in lower combustion efficiency

-Low temperature increases the viscosity of lubricant causing more loss due to friction

41. What is the firing order?

Answer: The order or sequence in which the firing takes place, in different cylinders of a multi-cylinder engine is called Firing Order.

In case of SI engines, the distributor connects the spark plugs of different cylinders according to Engine Firing Order.

Advantages:

(a) A proper firing order reduces engine vibrations
(b) Maintains engine balancing.
(c) Secures an even flow of power.

•Firing order differs from engine-to-engine.

•Probable firing orders for different engines are:

3 cylinder = 1-3-2
4 cylinder engine (inline) = 1-3-4-2 or 1-2-4-3
4 cylinder horizontal opposed engine = 1-4-3-2

42. What are the Ignition system of IC Engine?

Answer: Convectional Ignition systems are of 2 types:

(a) Battery or Coil Ignition System, and
(b) Magneto Ignition System

Another popular ignition system is- Electronic Ignition System.

43. Some important parameter comparison between diesel and petrol engine.

Engine Type	Thermal Efficiency	A/F Ratio[1]	Compression Ratio	Compression Pressure
Diesel	30-40%	$\frac{18}{1} \leq \frac{A}{F} \leq \frac{70}{1}$	12:1 to 24:1	30 to 50bar
Petrol	25-28%	$\frac{12}{1} \leq \frac{A}{F} \leq \frac{18}{1}$	8:1 to 12:1	7 to 15 bar

44. What does valve lead, lag and overlap mean?

Answer: Valve lead: This is where a valve opens so many degrees of crankshaft rotation before either TDC or BDC.

Valve lag: This is where a valve closes so many degrees of crankshaft rotation after TDC or BDC.

Valve overlap: This is the condition when both the inlet and the exhaust valves are open at the same time during so many degrees of crankshaft rotation.

43. What is DTSI Technology?

Answer: DTSI means Digital Twin Spark Plug Ignition. 'Digital' denotes that the spark generation will be initiated by a microchip. 'Twin' denotes that two spark plugs will be used and the 'Spark ignition' means the ignition will be done via a spark.

It results in efficient combustion of air fuel mixture.

45. Despite of being SI engines why different types of sound are produced from different bikes?

Answer: Due to the design difference of engine bore diameter, ignition timing and the exhaust silencer.

46. How HUCR is related with petrol engine?

Answer: HUCR is **Highest Useful Compression Ratio** at which the fuel can be used in a specific test engine, under specified operating conditions, without knocking.

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[1] Internal Combustion Engines Fundamentals - Heywood ξ 2.9

47. Which are the reference fuels for knock rating of S.I. engines?

Answer: n-heptane and ISO-octane

48. What does CC Stand for?

Answer: CC is the abbreviated form of cubic centimeter. It is the unit by which the capacity of an engine is designated. It is the volume between TDC and BDC. It represents the quantity of fuel-air mix or exhaust gas that is pumped out in a single piston stroke. Alternatively it can represent the volume of the cylinder itself.

49. What are the causes of black smoke in engine?

Answer: a) Improper mixure of fuel in carburetor.

b) Leakage of lubricant due to failure of pistion rings.

c) Improper ignition system like not sufficient time of pressure rise delay period.

50. Describe the engine model number: 16V34HLX

Answer: Number of cylinder: 16

Cylinder arrangement: Vee form (V)

Cylinder Bore: 340 mm

HLX: Manufacturer Series

51. How do you identify a petrol engine and a diesel engine?

Answer: Diesel engines are compression ignition and petrol engines are spark ignited one. If there is a spark plug its petrol engine or else it would be diesel engine. The presence of fins in the engine compartment also differentiates them apart as Diesel engines have and petrol does not.

52. Write the name of five systems of an engine.

Answer: (a) Air intake systems

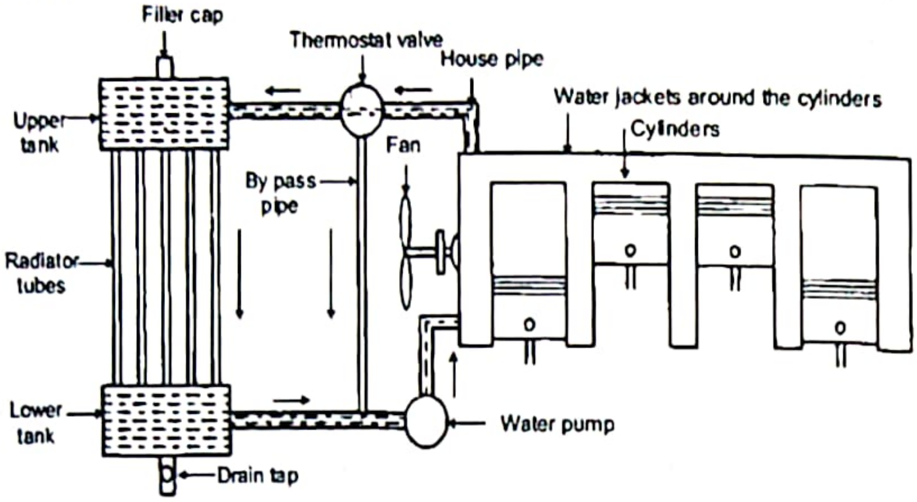
(b) Exhaust systems

(c) Cooling systems

(d) Lubrication systems

(e) Fuel systems

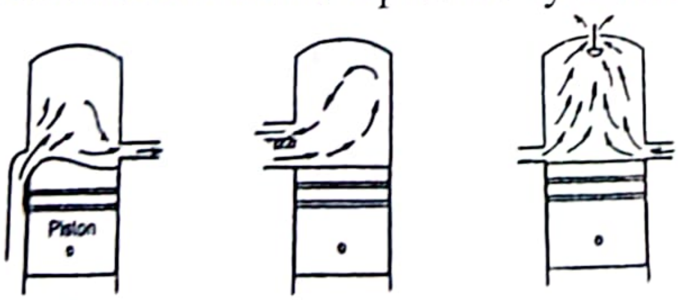
53. Draw cooling circuit diagram of a car.
Answer:



54. What is scavenging? What are the types of Scavenging?
Answer: Scavenging is the process of removing the burnt gases in I.C. engines from the combustion chamber of the engine cylinder.

There are many types of scavenging. But the followings are most important

1. **Cross flow scavenging (Fig. a):** In this method, the transfer port (or inlet port for the engine cylinder) and exhaust port are situated on the opposite sides of the engine cylinder (as in the case of two stroke cycle engines).
2. **Back flow or loop scavenging (Fig. b)**: In this method the inlet and outlet ports are situated on the same side of the engine cylinder.
3. **Uniflow scavenging (Fig. c):** In this method, the fresh charge, while entering from one side (or sometimes two sides) of the engine cylinder pushes out the gases through the exit valve situated on the top of the cylinder.



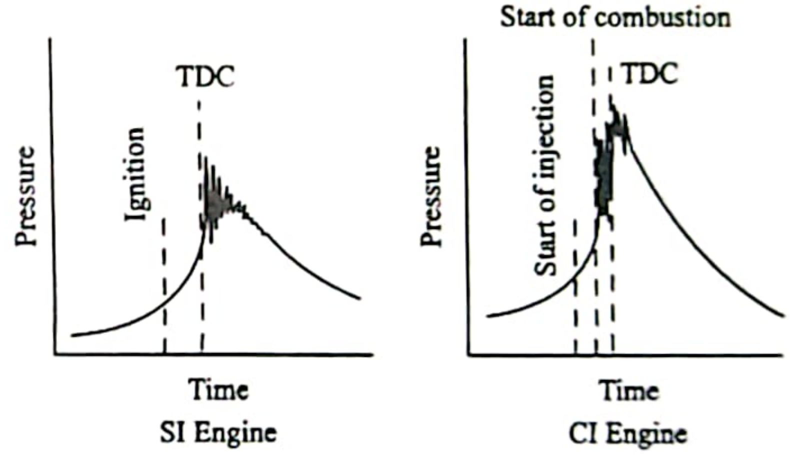
(a) (b) (c)

Fig. Types of scavenging

55. Explain the Knocking/Detonation phenomena.

Answer: The rapid auto-ignition of a portion of a fuel causes a pressure wave of high intensity to be set up in the cylinder of an I.C. engine. This pressure wave of high intensity propagates rapidly through the gas gives a violet blow to the walls of the cylinder, to the combustion chamber and to the piston. A loud pulsating noise known as knocking is produced which gives violent vibration to the engine. The term detonation is used to indicate precede of gas vibration and term knock is used to include all phenomenon that arise from auto-ignition. The knock in S.I. engines is characterized by sudden auto-ignition of the charge farthest away from the spark plug while in case of C.I. engines it is characterized by the sudden auto-ignition of the mixture at the very beginning of the combustion process.

Knocking in CI engine always occurs before TDC means initial phase of combustion and detonation in SI engine always occurs after TDC means last phase of combustion.



56. Lube oil এর কয়েকটি property বর্ণনা কর।

Viscosity Index: The viscosity index measure the variations in the viscosity with changes in temperature, the higher the level of viscosity index, the lower the variation of temperature.

Pour Point: The pour refers to the minimum temperature at which a lubricant/ oil continues to flow when cooled. Below the pour point, the oil tends to thicken and to ease to flow freely.

Flash Point: The flash point is the minimum temperature at which vapors from lubricants mixed with air and progressively heated in a standard laboratory receptacle, becomes inflammable.

Total Base Number (TBN): TBN is a property usually associated with engine oils. It is defined as the oils ability to neutralize acid. The higher the TBN the acid it is able to neutralize. This quality is also referred to as alkaline reserve and is directly proportional to the amount of active detergent contained in the oil.

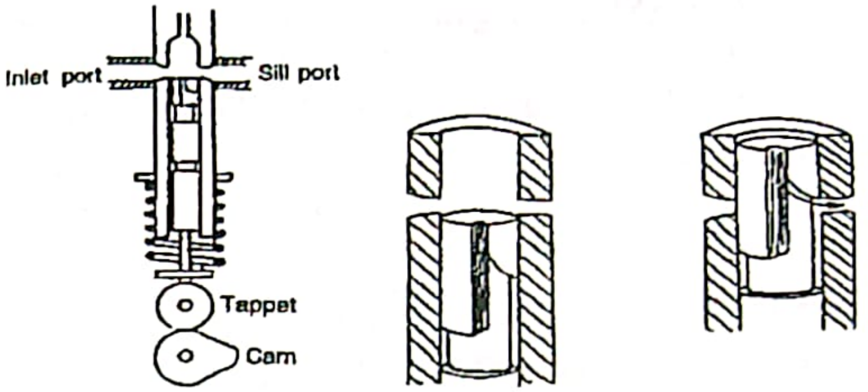
Total Acid Number (TAN): TAN is a property typically associated with industrial oils. It is defined as the amount of acid and acid like material in the oil. A high TAN number represents the potential for accelerated rust, corrosion and oxidation and is a signal that the oil should be replaced.

If TAN increases, TBN will decrease in used oil.

57. Explain the function of Fuel pump, Spark Plug and Injector.

Answer: Fuel pump: The main object of a fuel pump in a diesel engine is to deliver a fuel to the injector which sprays the finely divided particles of the suitable for rapid combustion. The simplified of a fuel pump is shown in Fig.(a). It consists of a plunger which moves up and down in the barrel by the cam and spring arrangement provided for pushing and lowering the plunger respectively. The fuel oil is highly filtered by means of felt-pack filter before entering the barrel of the pump.

The upper end part of the plunger is cut away in a helix shaped piece forming a groove between the plunger and barrel, which is the most important one. Therefore, the amount of fuel delivered and injected into the engine cylinder depends upon the rotary position of the plunger in the barrel. Fig. (b) and (c) shows how the top part of the plunger is designed so that the correct amount of fuel is delivered to the injector.

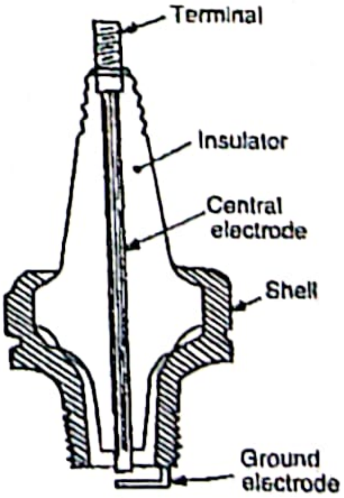


(*a*) Fuel pump. (*b*) Beginning of stroke. (*c*) End of stroke.

When the plunger is at the bottom of its stroke as shown (b), the fuel enters the barrel through the port. As the plunger rises, it forces this fuel up into the injector, until the upper part cut away comes opposite the sill port. Then the fuel escapes down the groove and out through the sill port so that injection ceases, as shown in Fig. (c). The plunger can be made to rotate in the barrel and therefore more fuel is injected. When the plunger is rotated so that the groove is opposite to the sill port, no fuel at all is injected and thus the engine stops.

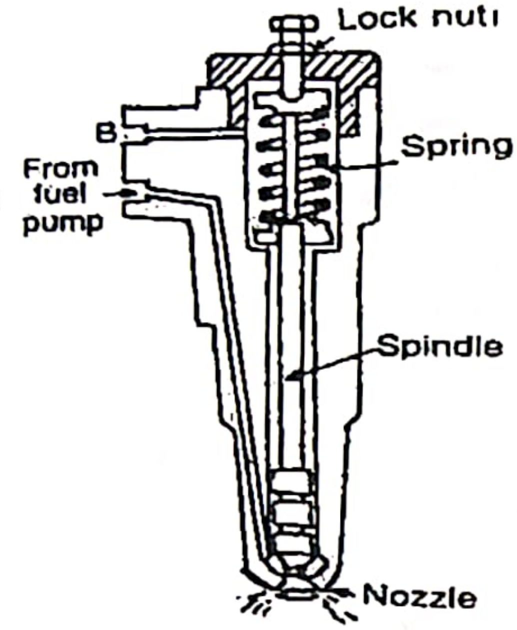
Spark plug:

It is always screwed into the cylinder head for igniting the charge of petrol engines. It is usually, design to with stand a pressure up to 35 bars and operate under a current of 10000 to 30000 volts. A spark plug consists of central porcelain insulator containing an axial electrode length wise and ground electrode welled to it. The central electrode has an external contact at the top.



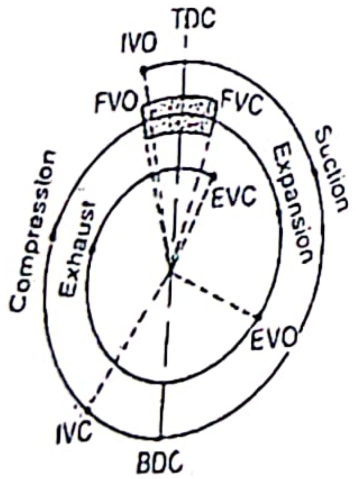
Injector or Atomizer:

The injector or atomizer is an important part of diesel engine which breaks up the fuel and sprays into the cylinder into very fine divided particles.



58. Draw the valve timing diagram for four stroke Diesel engine.

Answer:



TDC : Top dead centre

BDC : Bottom dead centre

IVO : Inlet valve opens (10° - 20° before *TDC*)

IVC : Inlet valve closes (25° - 40° after *BDC*)

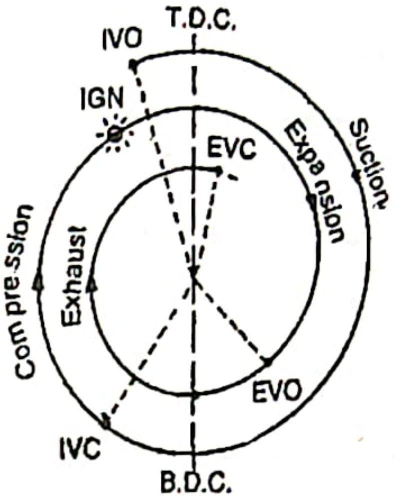
FVO : Fuel valve opens (10° - 15° before *TDC*)

FVC : Fuel valve closes (15° - 20° after *TDC*)

EVO : Exhaust valve opens (39° - 50° before *BDC*)

EVC : Exhaust valve closes (10° - 15° after *TDC*)

59. Draw the valve-timing diagram for four stroke Petrol.



TDC : Top dead centre

BDC : Bottom dead centre

IVO : Inlet valve opens (10°-20° before *TDC*)

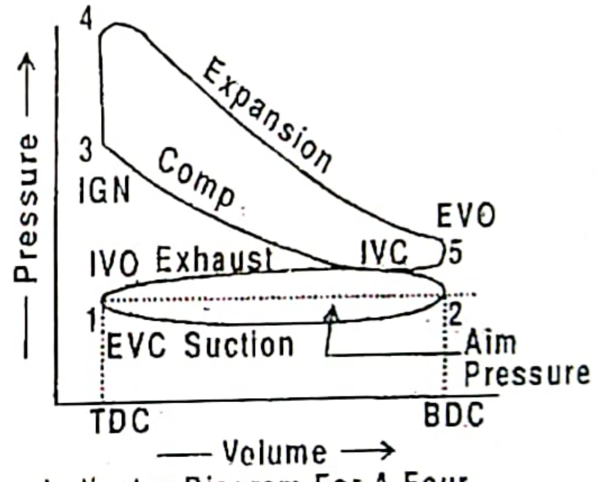
IVC : Inlet valve closes (30°- 40° after *BDC*)

IGN : Ignition (20°-30° before *TDC*)

EVO : Exit valve opens (30°-50° before *BDC*)

EVC : Exit valve closes (10°-15° after *TDC*)

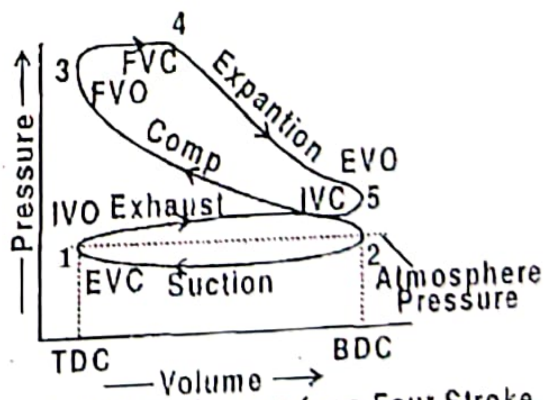
60. Draw the Indicator Diagram of SI engine.



Indicator Diagram For A Four Stroke Cycle Petrol Engine.

61. Draw the Indicator Diagram of CI engine.

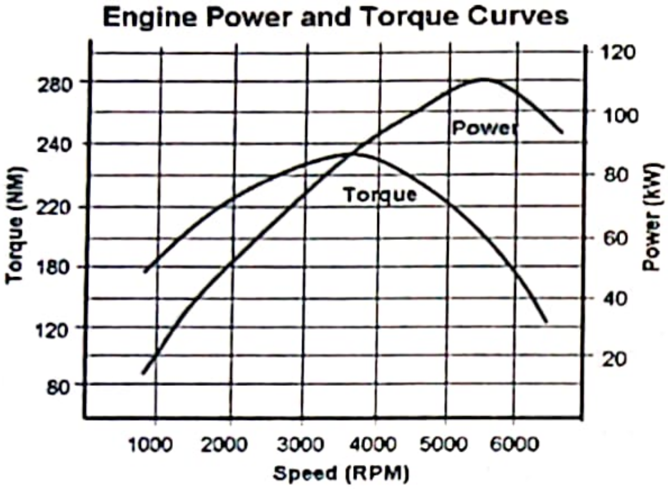
Answer:



Indicator diagram for a Four Stroke Cycle Diesel Engines.

62. Draw the characteristics curve of IC Engine.

Answer:



63. কিভাবে ইঞ্জিনের Brake Power measure করা হয়?

Answer: Brake power is measured by dynamometer.

64. What is honing of Cylinder Liners?

Answer: The head of the honing device consists of four synchronized stones. For the initial honing diamond stones are used to break up the hardened surface in the scuffed areas. For the main honing very coarse and hard stones are used to produce a very desirable rough surface all over the liner. The advantage, especially for the 2-stroke engines, is possibility to save the liner after a seizure, scuffing or blow-by or even to eliminate the ovality of the liner. Another advantage is that it is possible to machine a rough liner wall to obtain a well oiled surface.

অধ্যায় ৪

Refrigeration

1. What is Refrigeration?

Answer: Refrigeration is a process of removing heat from a low temperature region and transforming it to a high temperature region.

Or, Refrigeration is the process of extraction heat from a body where temperature is already below the temperature of its surroundings.

The amount of heat removed from the region (or from the body) is known as refrigeration effect.

2. একটা refrigeration system এর component গুলোর নাম বলো।

Answer: (a) The compressor

(b) The cooler or heat exchanger.

(c) The expander (expansion valve) and

(d) The refrigerator (evaporator)

3. বাসা বাড়ির ফ্রিজে খাবার কোথায় রাখা হয়?

Answer: Evaporator এ।

4. Define the unit of refrigerator (TR)?

Answer: Tonne of refrigeration: A tonne of refrigeration is defined as the amount of refrigeration effect produced by the uniform melting of one tonne (1000 kg) of ice from and at 0°C in 24 hours. Since the latent heat of ice is 335 kJ/kg therefore, one tonne of refrigeration

$1\ TR = 1000 \times 335$ KJ in 24 hours

$= (1000 \times 335)/(24 \times 60) = 232.6$ KJ/ min

In actual practice one tonne of refrigeration is taken as equivalent to 210 KJ/min or 3.5 KW

5. Define COP.

Answer:

Coefficient of performance of a refrigerator (COP):

The coefficient of performance is the ratio of heat extracted in the refrigerator to the work done on the refrigerant.

Theoretically COP = Q/W

Q = Amount of heat extracted in the refrigerator (or the amount of refrigeration produced or the capacity of a refrigerator)

W = Amount of work done

6. Define EPR (Energy Performance Ratio)?

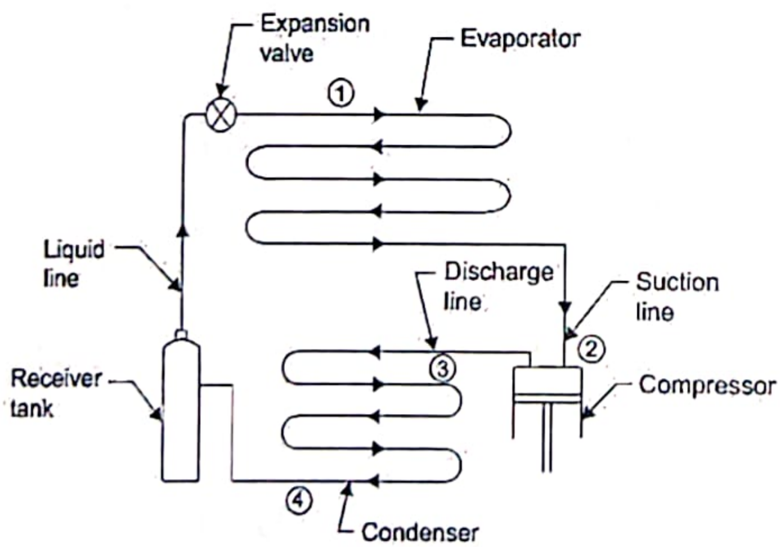
Answer: The performance of a heat pump is expressed by the ratio of the amount of heat delivered to the hot body to the amount of work required to be done on the system. This ratio is called coefficient of performance or energy performance ratio of heat pump.

EPR=COP (for refrigerator) + 1

7. Draw a schematic diagram of Vapor compression refrigeration cycle

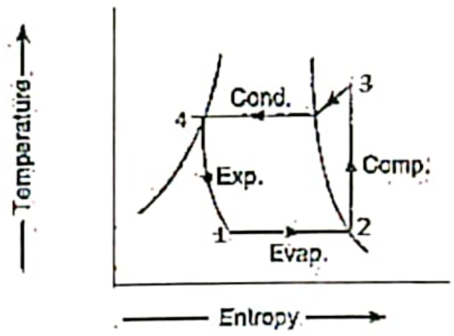
Answer: In a simple vapour compression system fundamental processes are completed in one cycle.

These are: 1. Compression, 2. Condensation, 3. Expansion and 4. Vaporization.

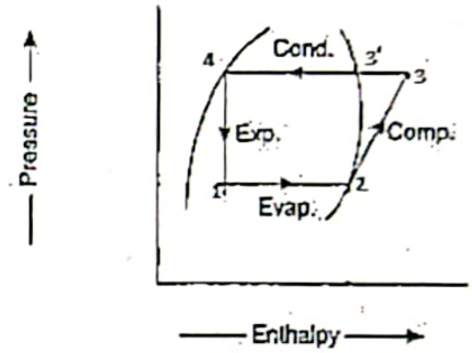


8. Draw T-S and p-h diagram of a vapor compression refrigeration system and explain it.

Answer: The vapour at low temperature and pressure (state '2') enters the "compressor" where it is compressed isentropically and subsequently its temperature and pressure increase considerably (state '3').



T–S Diagram



p–h Diagram

This vapour after leaving the compressor enters the "condenser" where it is condensed into high pressure liquid (state '4') and is collected in a "receiver tank". From receiver tank it passes through the "expansion valve", here it is throttled down to a lower pressure and has a low temperature (state '1'). After finding its way through expansion "valve" it finally passes on to "evaporator" where it extracts heat from the surroundings or circulating fluid being refrigerated and vaporizes to low pressure vapour (state '2').

9. Describe the functions of different Parts of a Simple Vapour Compression Syste.

Here follows the brief description of various parts of a simple vapour compression system

1. Compressor: The function of a compressor is to remove the vapour from the evaporator and to raise its temperature and pressure to a point such that it (vapour) can be condensed with available condensing media.

2. Discharge line (or hot gas line): A hot gas or discharge line delivers the high-pressure, high-temperature vapour from the discharge of the compressor to the condenser.

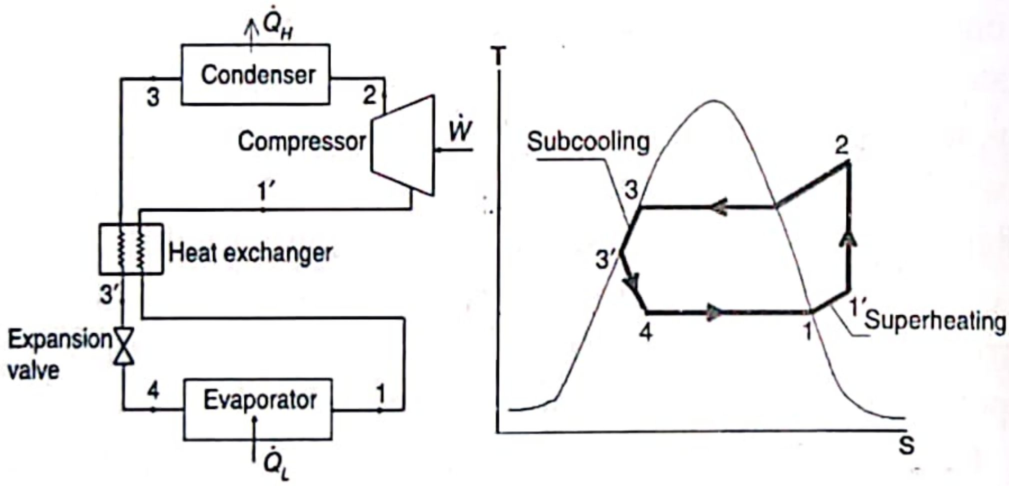
3. Condenser: The function of a condenser is to provide a heat transfer surface through which heat passes from the hot refrigerant vapour to the condensing medium.

4. Receiver tank: A receiver tank is used to provide storage for a condensed liquid so that a constant supply of liquid is available to the evaporator as required.

5. Liquid line: A liquid line carries the liquid refrigerant from the receiver tank to the refrigerant flow control.

6. Expansion valve (refrigerant flow control): Its function is to meter the proper amount of refrigerant to the evaporator and to reduce the pressure of liquid entering the evaporator so that liquid will vaporize in the evaporator at the desired low temperature and take out sufficient amount of heat.

7. Draw a schematic diagram of vapor compression refrigeration with Subcooling and Superheating.



8. What are the main components of a vapor absorption refrigeration Cycle?

Answer: Major Components: (i) Absorber (ii) Generator (iii) Condenser (iv) Evaporator (v) Expansion valve and (vi) Pump.

9. Which accessories are used in vapor absorption refrigeration system to improve its performance?

Answer: The following accessories are fitted to make the system more practical and improve the performance and working of the plant.

1. Heat exchanger. 2. Analyser. 3. Rectifier.

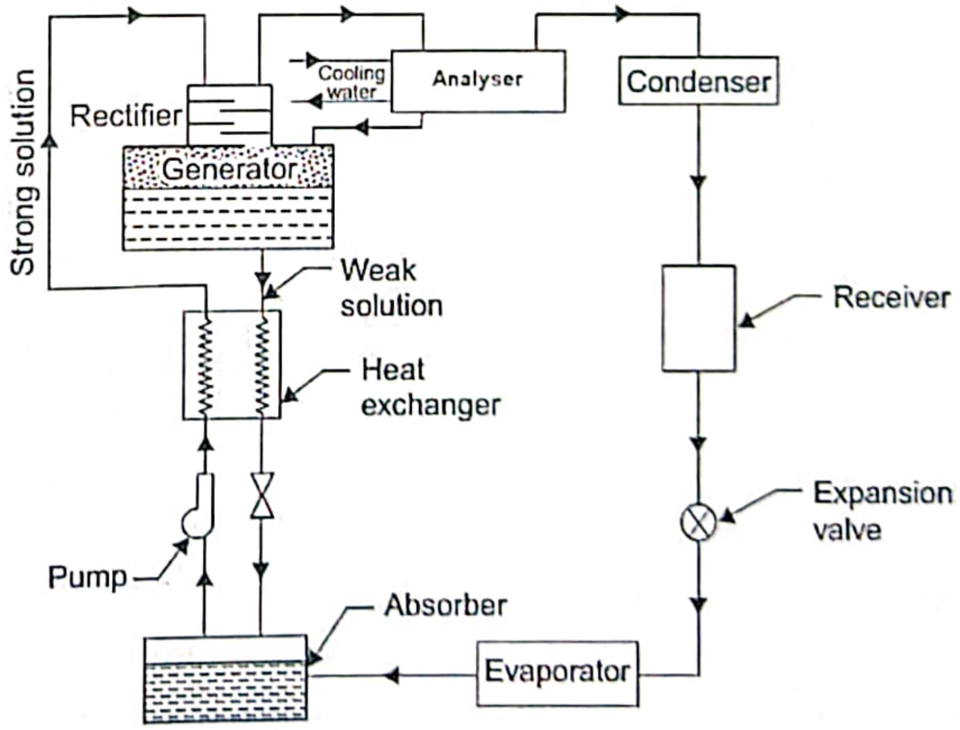
1. Heat exchanger: A heat exchanger is located between the generator and the absorber. The strong solution which is pumped from the absorber to the generator must be heated and the weak solution from the generator to the absorber must be cooled. This is accomplished by a heat exchanger and consequently cost of heating the generator and cost of cooling the absorber are reduced.

2. Analyser: An analyser consists of a series of trays mounted above the generator. Its main function is to remove partly some of the unwanted water particles associated with ammonia vapour going to condenser. If these water vapours are permitted to enter condenser they may enter the expansion valve and freeze, as a result the pipe line may get choked.

3. Rectifier: A rectifier is a water-cooled heat exchanger which condenses water vapour and some ammonia and sends back to the generator. Thus final reduction or elimination of the percentage of water vapour takes place in a rectifier.

10. Draw a schematic diagram of a vopor absorption refrigeration system.

Answer:



11. What is used as refrigerant and as absorbent in an ammonia-water and LiBr-water vapor absorption refrigeration system.

Answer:

Absorption Refrigeration System	Absorbent	Refrigerant
Ammonia-Water	Water	Ammonia
LiBr- Water	LiBr	Water

12. Define the Air Conditioning system.

Answer: The air conditioning is that branch of engineering science, which deals with the study of conditioning of air i.e. supplying and maintaining desirable internal atmospheric conditions for human comfort, irrespective of external conditions.

13. What are the Factors affecting Comfort air conditioning?

Answer:

(i) Temperature of air
(ii) Humidity of air
(iii) Purity of air
(iv) Motion of air
(v) Clothing
(vi) Sex and age
(vii) Activity

14. What are the equipment used in an air conditioning System?

Answer:

a) **Circulation fan**: The main function of this fan is to move air to and from the room.
b) **Air conditioning unit**: It is a unit, which consists of cooling and dehumidifying processes for summer air conditioning or heating and humidification process for winter air conditioning.

c) **Supply Duct**: It directs the conditioned air from the circulating fan to the space to be air conditioned at proper point.
d) **Supply outlets**: These are grills, which distribute the conditioned air evenly in the room.
e) **Return outlets**: These are the openings in a room surface which allow the room air to enter the return duct.
f) **Filters**: The main function of the filters is to remove dust, dirt and other harmful bacteria from the air.

15. Classify the Air Conditioning Systems?

Answer: The air conditioning systems may be broadly classified as follows:

1. According to the purpose

(a) Comfort air conditioning system, and
(b) Industrial air conditioning system.

2. According to season of the year

(a) Winter air conditioning system,
(b) Summer air conditioning system, and
(c) Year-round air conditioning system.

3. According to the arrangement of equipment

(a) Unitary air conditioning system and
(b) Central air conditioning system.

16. What are the major components of a central air conditioning system?

Answer: Major Components: (i) Chiller (a complete vapor compression or absorption refrigeration system) (ii) Air Handling Unit (AHU) (iii) Cooling Tower.

In a chilled-water system, the entire air conditioner (chiller) lives on the roof or behind the building. The chiller cools water to between 4°C to 7°C. This chilled water is then piped throughout the building and connected to air handling units (AHUs) as needed. The AHU cools the air by using this chilled water and supply the cooled air through ducts to the conditioned space.

Central air conditioning units range in capacity from about 15 to 3500 tons of refrigeration.

16. Define HVAC System.

Answer: HVAC is in common use in the heating and cooling industry. It stands for "heating, ventilation and air conditioning," An HVAC system is responsible for moderating the temperature of a building's interior and maintaining it at a comfortable level for the inhabitants. During the hot days of summer, the air conditioning kicks in, providing much-needed cool air. In the frigid days of winter, the system supplies heat.

17. What are the main parts of HVAC system?

Answer: Furnace: The furnace unit is typically fairly large, requiring its own space within a building. It is often installed in the basement, in the attic, or in a closet. The furnace pushes the cold or hot air outward into the ducts that run through every room in the building. Throughout the ducts, there are vents that allow the warm or cool air to pass into rooms and change their interior temperature.

Heat exchanger: While often confused for a part of the furnace, because it resides in the furnace, the heat exchanger should be considered as a separate component. The heat exchanger adds heat to incoming cool air from the air in the combustion chamber.

Evaporator coil: The indoor coil of your air conditioning system also resides in the furnace unit. A cold refrigerant runs through the coil, which absorbs heat from air passing over it. The cold air is then blown through the ducts into your home.

Condensing unit: In most systems, there is an outdoor unit shaped like a cube. Inside of it there is the condensing coil. Just like the evaporator coil, it exchanges heat with air that passes over it, but in this case, it gives off heat.

Refrigerant tubes: These lines are made of metal and connect the evaporator coil with the condensing coil. They are designed to contain refrigerant under a wide range of temperatures.

Thermostat: The thermostat is a small unit connected to your HVAC system. Depending on what temperature you have set it at, it tells your air conditioning or heating system to turn on and run.

Ductwork: Ducts are responsible for moving air all around your home. Air comes into your HVAC system through certain sections of ductwork, and is distributed to rooms through others.

Vents: Once the air travels through the ductwork, it enters rooms through vents. Vents are rectangular covers that can direct or block air. There are also return vents where air is taken into the ducts.

18. What is Refrigerant?

Answer: Refrigerant is the substance which is used for heat transfer in a refrigeration system. It picks up heat by evaporation at a low temperature and pressure and gives up this heat by condensing at higher temperature and pressure.

19. Classify the Refrigerant.

1. Primary refrigerant
2. Secondary refrigerant

Primary Refrigerant: To complete the cycle, the refrigerant is used is known as primary refrigerant.

Secondary Refrigerant: The refrigerants which are first cooled by primary refrigerants and then used for cooling purposes are known as secondary refrigerant.

Types of primary refrigerant:

1. Halo carbon refrigerant
2. Inorganic refrigerant
3. Hydrocarbon refrigerant
4. Agitrops refrigerant (Two or more refrigerant mixer and has a different properties from its mixing components)

20. What are the selection criteria of a refrigerant?

Answer: Selection of refrigerant for a particular application is based on the following requirements:

i. Thermodynamic and thermo-physical properties

ii. Environmental and safety properties and
iii. Economics

21. What the thermodynamics and thermo-physical properties of a refrigerant?

Answer: The requirements are:

a) Suction pressure: At a given evaporator temperature, the saturation pressure should be above atmospheric for prevention of air or moisture ingress into the system and ease of leak detection. Higher suction pressure is better as it leads to smaller compressor displacement.

b) Discharge pressure: At a given condenser temperature, the discharge pressure should be as small as possible to allow light-weight construction of compressor, condenser etc.

c) Pressure ratio: Should be as small as possible for high volumetric efficiency and low power consumption.

d) Latent heat of vaporization: Should be as large as possible so that the required mass flow rate per unit cooling capacity will be small.

In addition to the above properties; the following properties are also important:

e) Isentropic index of compression: Should be as small as possible so that the temperature rise during compression will be small.

f) Liquid specific heat: Should be small so that degree of sub-cooling will be large leading to smaller amount of flash gas at evaporator inlet.

g) Vapour specific heat: Should be large so that the degree of superheating will be small.

h) Thermal conductivity: Thermal conductivity in both liquid as well as vapour phase should be high for higher heat transfer coefficients.

i) Viscosity: Viscosity should be small in both liquid and vapour phases for smaller frictional pressure drops.

22. What the Environmental and safety properties of a refrigerant?

Answer: Next to thermodynamic and thermo physical properties, the environmental and safety properties are very important. The important environmental and safety properties are:

a) Ozone Depletion Potential (ODP): According to the Montreal protocol, the ODP of refrigerants should be zero. Since ODP depends mainly on the presence of chlorine or bromine in the molecules, refrigerants having either chlorine (i.e., CFCs and HCFCs) or bromine cannot be used under the new regulations.

b) Global Warming Potential (GWP): Refrigerants should have as low a GWP value as possible to minimize the problem of global warming. Refrigerants with zero ODP but a high value of GWP are likely to be regulated in future.

c) Total Equivalent Warming Index (TEWI): The factor TEWI considers both direct (due to release into atmosphere) and indirect (through energy consumption) contributions of refrigerants to global warming. Naturally, refrigerants with as a low a value of TEWI are preferable from global warming point of view.

d) Toxicity: Ideally, refrigerants used in a refrigeration system should be non-toxic. However, all fluids other than air can be called as toxic as they will cause suffocation when their concentration is large enough. Thus toxicity is a relative term, which becomes meaningful only when the degree of concentration and time of exposure required to produce harmful effects are specified.

e) Flammability: The refrigerants should preferably be non-flammable and non-explosive. For flammable refrigerants special precautions should be taken to avoid accidents.

f) Chemical stability: The refrigerants should be chemically stable as long as they are inside the refrigeration system.

g) Compatibility: with common materials of construction (both metals and non-metals)
this happens.

h) Miscibility with lubricating oils: Oil separators have to be used if the refrigerant is not miscible with lubricating oil (e.g. ammonia). Refrigerants that are completely miscible with oils are easier to handle.

i) Dilelectric strength: This is an important property for systems using hermetic compressors. For these systems the refrigerants should have as high a dielectric strength as possible.

j) Ease of leak detection: In the event of leakage of refrigerant from the system, it should be easy to detect the leaks.

23. What is the designation system of refrigerants?

Answer:

i) Fully saturated, halogenated compounds:

These refrigerants are derivatives of alkanes (C_nH_{2n+2}) such as methane (CH_4), ethane (C_2H_6). These refrigerants are designated by R XYZ, where: X+1 indicates the number of Carbon (C) atoms.

Y-1 indicates number of Hydrogen (H) atoms, and

Z indicates number of Fluorine (F) atoms

The balance indicates the number of Chlorine atoms. Only 2 digits indicates that the value of X is zero.

Example: R 22

X = 0 ⇒ No. of Carbon atoms = 0+1 = 1 ⇒ derivative of methane (CH_4)

Y = 2 ⇒ No. of Hydrogen atoms = 2-1 = 1

Z = 2 ⇒ No. of Fluorine atoms = 2

The balance = 4 – no. of (H+F) atoms = 4-1-2 = 1 ⇒ No. of Chlorine atoms = 1

∴The chemical formula of R 22 = $CHClF_2$

Similarly it can be shown that the chemical formula of:

R12 = CCl_2F_2
R134a = $C_2H_2F_4$ (derivative of ethane)
(letter 'a' stands for isomer, e.g. molecules having same chemical composition but different atomic arrangement, e.g. R134 and R134a)

ii) Inorganic refrigerants: These are designated by number 7 followed by the molecular weight of the refrigerant (rounded-off).

Example: Ammonia: Molecular weight is 17, so the designation is R 717

Carbon dioxide: Molecular weight is 44, so the designation is R 744

Water: Molecular weight is 18, so the designation is R 718

iii) Mixtures: Azeotropic mixtures are designated by 500 series, where as zeotropic refrigerants (e.g. non-azeotropic mixtures) are designated by 400 series.

Azeotropic mixtures:

R 500: Mixture of R 12 (73.8 %) and R 152a (26.2%)
R 502: Mixture of R 22 (48.8 %) and R 115 (51.2%)
R503: Mixture of R 23 (40.1 %) and R 13 (59.9%)
R507A: Mixture of R 125 (50%) and R 143a (50%)

Zeotropic mixtures:

R404A : Mixture of R 125 (44%), R 143a (52%) and R 134a (4%)
R407A : Mixture of R 32 (20%), R 125 (40%) and R 134a (40%)
R407B : Mixture of R 32 (10%), R 125 (70%) and R 134a (20%)
R410A : Mixture of R 32 (50%) and R 125 (50%)

iv) Hydrocarbons:

Propane (C_3H_8) : R 290
n-butane (C_4H_{10}) : R 600
iso-butane (C_4H_{10}) : R 600a
Unsaturated Hydrocarbons: R1150 (C_2H_4)
R1270 (C_3H_6)

24. How you identify the leakage of a refrigerant.

Answer: Refrigeration system leak detection may be carried out by applying the following method:

1. Soap bubble method
2. Odor detect method
3. Color detect method
4. Halide light method

25. What are the defrosting method of an Evaporator:

Answer:

a) Manual defrosting method
b) Pressure control defrosting method
c) Temperature control defrosting method
d) Water defrosting method
e) Reverse cycle defrosting method
f) Simple hot gas defrosting method
g) Automatic hot gas defrosting method
h) Thermo bank defrosting method
i) Electric defrosting method

26. Dry air, Moist air এবং Saturated air এর মধ্যে পার্থক্য কি?

Answer: Dry air: The pure dry air is a mixture of number of gases such as nitrogen, oxygen, carbon-dioxcide, hydrogen, argon, neon, helium etc.

But the nitrogen and oxygen have the major portion of the combination.

Moist air: It is a mixture of dry air and water vapour. The amount of water vapour, present in the air, depends upon the absolute pressure and temperature of the mixture.

Saturated air: It is a mixture of dry air and water vapour, when the air has diffused the maximum amount of water vapour into it.

27. What is Degree of saturation?

Answer: It is the ratio of actual mass of water vapour in a unit mass of dry air to the mass of water vapour in the same mass and pressure of dry air when it is saturated at the same temperature.

28. Define Humidity relative humidity and absolute humidity.

Answer: Humidity: It is the mass of water vapor present in 1 kg of dry air and is generally expressed in kg/kg of dry air. It may also be defined as the ratio of mass of water vapor to the mass of dry air in a given volume of the air vapor mixture. Mathematically Humidity,

$$W = 0.662 \times \frac{p_v}{p_a}$$

Relative humidity: Relative humidity is the ratio of actual mass of water vapor (m_v) in a given volume of moist air to the mass of water vapor (m_s) in the same volume of saturated air at the same temperature and pressure. Mathematically relative humidity,

$$R = \frac{m_v}{m_s} = \frac{p_v}{p_s}$$

Absolute humidity: It is the mass of water vapour present in 1 m^3 of dry air, and is generally expressed in terms of gm per cubic metre of dry air.

29. What is Dew Point Temperature, Dry bulb temperature, Wet bulb temperature, Dew point depression and Dew point depression.

Answer: Dew Point Temperature: Dew point temperature has a saturation pressure equal to the pressure of water vapor in the air. From steam table we find that the temperature corresponding to 14mm of Hg is 16.4 degree Celsius.

Dry bulb temperature: It is the temperature of air recorded by a thermometer, when it is not affected by the moisture present in the air. The dry bulb temperature is generally denoted by t_d or t_{db}.

Wet bulb temperature: It is the temperature of air recorded by a thermometer, when its bulb is surrounded by a wet cloth exposed to the air. Such a thermometer is called Wet bulb thermometer. The wet bulb thermometer is generally denoted by t_w or t_{wb}.

Wet bulb depression: It is the difference between dry bulb temperature and wet bulb temperature at any point. The wet bulb depression indicates relative humidity of the air.

Dew point depression: It is the difference between the dry bulb temperature and dew point temperature of air.

30. What is a Psychrometric chart?

Psychrometric chart is a nomogram which shows the graphical representation of the properties of moist air. The lines, that the chart contains, are as follows:

(i) **Wet bulb temperature lines:** These lines are inclined, straight and non-uniformly speed.

(ii) **Relative humidity** lines are curved.

(iii) **Volume lines** are straight inclined lines.

(iv) **Humidity ratio lines** are straight, parallel, horizontal and uniformly spaced.

(v) **Dry bulb temperature lines** are straight, parallel, vertical and uniformly spaced.

31. What are the Psychrometric processes?

Answer: The following are the main psychrometric processes:

(i) Sensible heating or cooling.

(ii) Humidification or dehumidification.

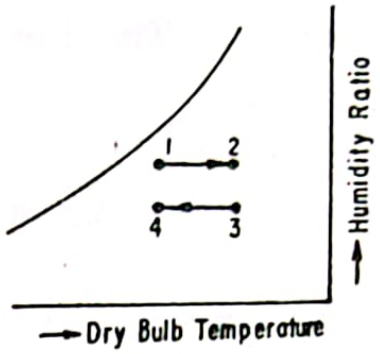
(iii) Cooling and dehumidification.

(iv) Heating and humidification.

(v) Adiabatic or evaporative cooling.

(vi) Chemical dehumidification.

(i) Sensible heating or cooling: The process of adding heat or moist air without changing the moisture (or humidity ratio) is called sensible heating, whereas the process of removing heat from moist air without changing the moisture content (or humidity ratio) is called sensible cooling. The line 1-2 shows sensible heating and line 3-4 shows sensible cooling.



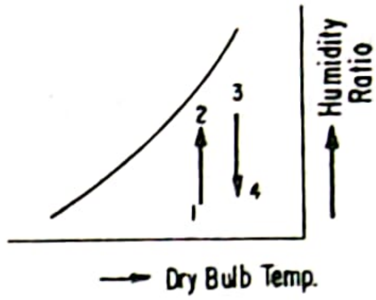
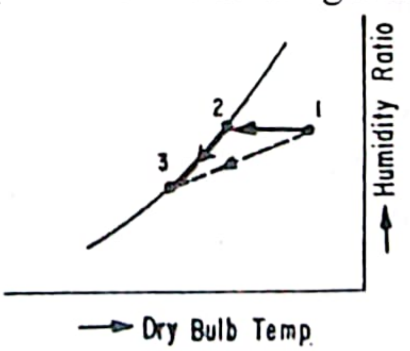


Fig.(i): Sensible heating or cooling **Fig.(ii): Humidification or dehumidification**

(ii)Humidification or dehumidification: The process of adding moisture at constant dry bulb temperature to moist air is called humidification, whereas the process of removing moisture at constant dry bulb temperature from the moist air is called dehumidification. In Fig. the line 1-2 shows the process of humidification whereas the line 3-4 shows the process of dehumidification. During humidification process relative humidity increases whereas during dehumidification process relative humidity decreases.

(iii) Cooling and dehumidification process of moist air as shown in figure. When the moist air is cooled below its dew point temperature, the condensation takes place. Line 1-2 represents cooling of moist air at constant humidity ratio upto dew point temperature.

Line 2-3 represents further cooling of the air. The line 1-3 represents the cooling and dehumidification process.



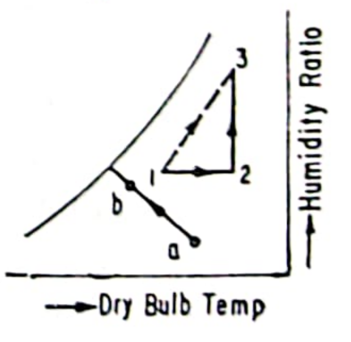


Fig.(iii): Cooling and dehumidification **Fig.(iv): Heating and humidification process**

(iii)**Heating and humidification process** of moist air is shown in figure. Line 1-2 shows heating at constant humidity ratio and line 2-3 shows the humidification

process at constant dry bulb temperature. The line 1-3 shows the heating and humidification process.

32. State some applications of Refrigeration.

Answer: **Refrigeration** of food stuffs in homes, restaurants and large storage warehouses.

- **Air-conditioning** of private homes and public buildings.
- **Cold-storage of fruits**, vegetables, fish and meats safely for long periods.
- **Meats, poultry** and fish all must be kept in climate-controlled environments before being sold.
- **Refrigeration** also helps keep fruits and vegetables edible longer. Dairy products are constantly in need of refrigeration.
- **To liquefy gases** like oxygen, nitrogen, propane and methane for example.
- **In oil refineries**, chemical plants, and petrochemical plants, refrigeration is used to maintain certain processes at their required low temperatures.
- **Metal workers** use refrigeration to temper steel and cutlery.
- **In transporting** temperature-sensitive foodstuffs and other materials by trucks, trains, airplanes and sea-going vessels.

33. Classify the Refrigeration System.

Answer:

1. Vapor Compression Refrigeration System
2. Vapor Absorption Refrigeration System
3. Vapor Ejection Refrigeration System
4. Air Cycle Refrigeration
5. Vortex Tube Refrigeration
6. Thermo-electric Refrigeration
7. Thermo-acoustics Refrigeration
8. Magnetic Refrigeration
9. Cascade System
10. Cryogenics

34. What are the limitations of single stage vapour compression refrigeration systems?

Answer: As evaporator temperature decreases:

i. Throttling losses increase

ii. Superheat losses increase

iii. Compressor discharge temperature increases

iv. Quality of the vapour at the inlet to the evaporator increases

v. Specific volume at the inlet to the compressor increases

35. Classify the multistage refrigeration system.

Answer:

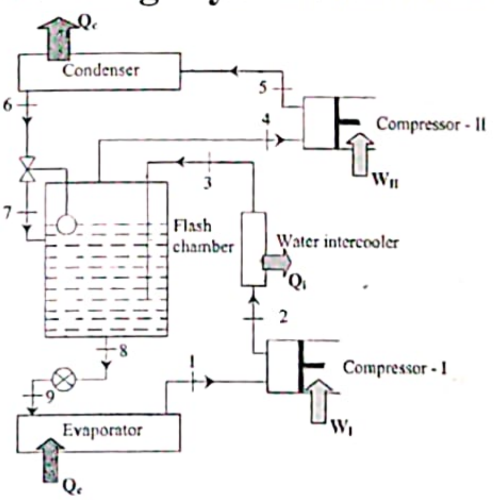
a) Multi-compression systems

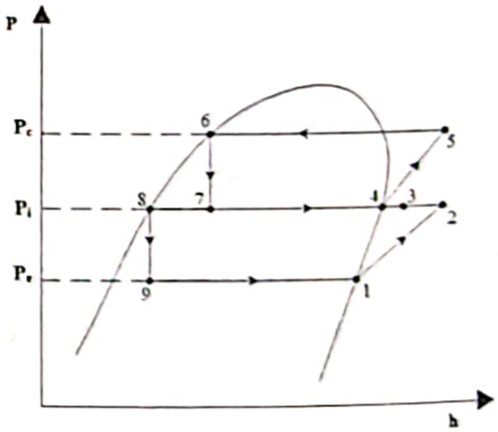
b) Multi-evaporator systems

c) Cascade systems, etc.

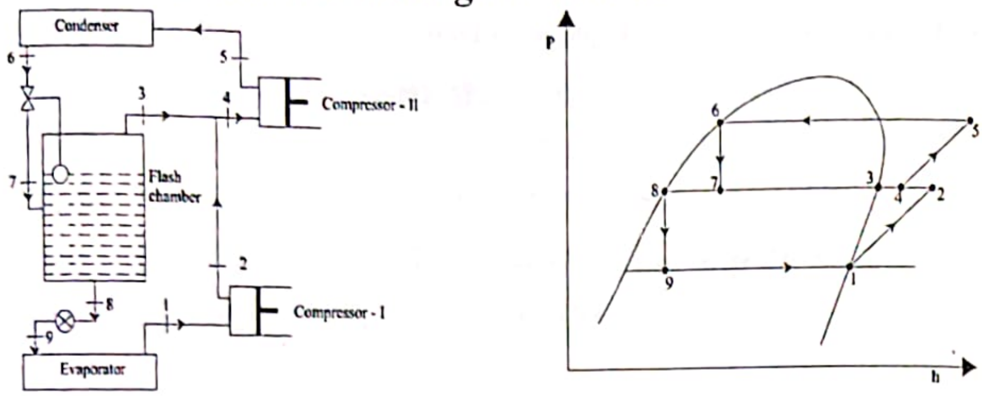
Two concepts which are normally integral to multi-pressure systems are, i) flash gas removal, and ii) intercooling.

Multi-stage system with flash gas removal and intercooling

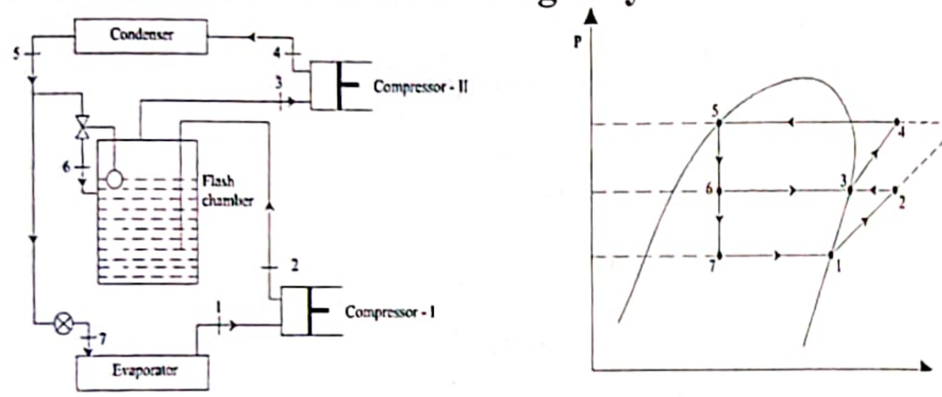




Use of flash tank for flash gas removal



Use of flash tank for intercooling only

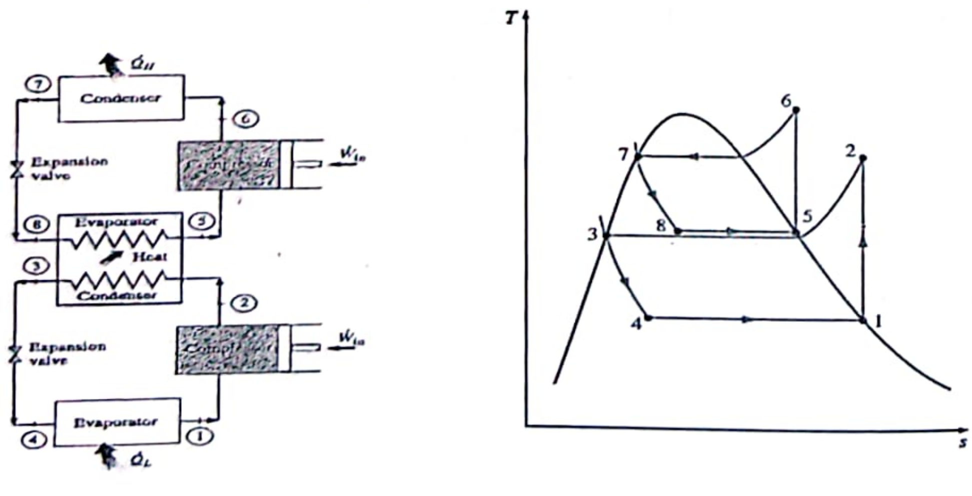


36. State some applications of cascade refrigeration system.

Answer:

i. Liquefaction of petroleum vapours
ii. Liquefaction of industrial gases
iii. Manufacturing of dry ice
iv. Deep freezing etc.

37. Draw schematic diagram of a cascade refrigeration system with T-S diagram.



38. What is Azetropes?

Answer: Azeotrope, in chemistry, a mixture of liquids that has a constant boiling point because the vapour has the same composition as the liquid mixture. The boiling point of an azeotropic mixture may be higher or lower than that of any of its components. They possess fixed thermodynamic properties and do not undergo any separation with changes in temperature and pressure. An azeotrope behaves like a simple substance. For refrigeration: blend of two or more component refrigerants whose equilibrium vapor-phase and liquid-phase compositions are the same at a given pressure.

Example: R-500. It contains 73.8% of (R-12) and 26.2% of (R-152).

39. Explain cryogenic Refrigeration system?

Answer: The branches of physics and engineering that study very low temperatures, how to produce them, and how materials behave at those temperatures. Temperature at cryogenic region is below 120K (-153°C)

Cryogenic Liquids: super-freezing permanent gases to liquid states, ex: oxygen, nitrogen, hydrogen, and helium.

- Liquid Nitrogen: most easily available
- Liquid Helium: lowest temp. <2.17K

40. What are the Super Cooled Materials?

Answer: Supercooling is the process of chilling a liquid below its freezing point, without it becoming solid. A super-cooled liquid is a liquid below its freezing point that has not crystalized to freeze. Glass is an example of supercooled liquid.

41. Full form of ASHRAE, BTU, ACH, FCU, HVAC, AHU

Answer:

ASHRAE- American Society of Heating, Refrigerating and Air-Conditioning Engineers

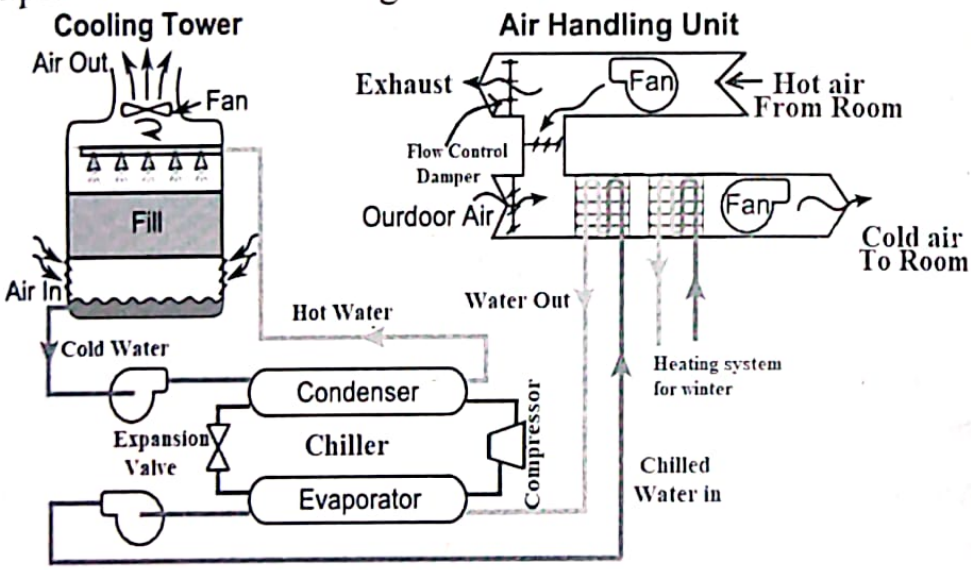
BTU-British thermal unit

ACH- Air Changes per Hour
FCU- Fan Coil Unit
HVAC- Heating, ventilation, and air conditioning
AHU- Air Handling Unit
VAV- Variable Air Volume
TOR- Time out of Refriegeration
VRF- Variable Refrigerant Flow

42. What is chiller? How the capacity of a chiller is measured?

Answer: Chilled water is used to cool products and machinery of different industrial applications such as food and beverage, chemicals, lasers, machine tool, injection molding, tool and die cutting, semi-conductors etc.

Another wide application of a chiller is in HVAC system. An example with schematic diagram is shown below:



Types of Chiller:

1. **Air-cooled:** It uses ambient air to cool the refrigerant and condense it back down to a liquid. It can be located inside the chiller or outside the chiller with a basic purpose that it rejects the heat from the chiller to the air.
2. **Water-cooled:** In a water-cooled condenser, water from a cooling tower cools and condenses the refrigerant.

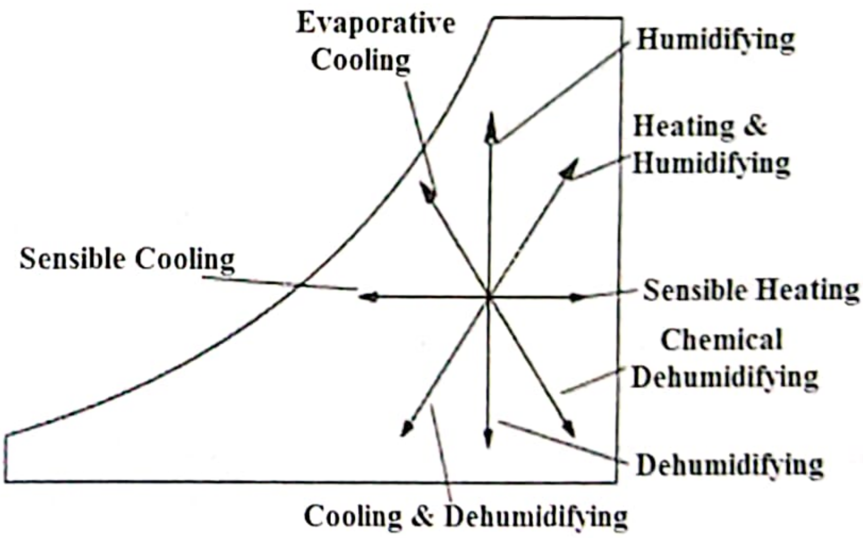
43. Write the difference between Refrigeration and Air-Conditioning.

Answer:

Refrigeration	Air Conditionar
1.Refrigeration removes heat from enclosed space	1. AC cools air and it circulates in the enclosed space.
2. Refrigeration has no air quality control system.	2. AC controls the air quality for human comfort
3. No humidifier or dehumidifier used in refrigerator.	3. Humidifier or dehumifier is used in AC.

44. Show different process on a psychometric chart.

(i) Heating and humidification
(ii) Sensible heating
(iii) Chemical dehumidification
(iv) Evaporative cooling



45. A sling hygrometer shows the dry bulb temperature and wet bulb temperature is same and that is 32°C. Find the i) Relative humidity, ii) Wet bulb depression and iii) dew point temperature.

Solution: Since, the dry bulb and wet bulb temperature is same

So, (i) Relative Humidity, $R = \frac{f}{F} = 100\%$ **(Ans.)**

(ii) Wet bulb depression = Dry blub temperature – wet bulb temperature = 0 **(Ans.)**

(iii) Dew point temperature = 32°C **(Ans.)**

46. What is the range of relative humidity for saturated air.

Answer: The relative humidity ranges from 0 for dry air to 1 for saturated air.

47. At 100% humidity what will be wet bulb temperature? If humidity reduced then what will be the wet bulb temperature?

Answer: At 100% humidity wet bulb temperature will be same. If humidity is reduced then wet bulb temperature will be reduced.

48. DescribeVRF based central air conditioning system.

Answer: VRFs are typically installed with an air conditioner inverter which adds a DC inverter to the compressor in order to support variable motor speed and thus variable refrigerant flow rather than simply perform on/off operation. By operating at varying speeds, VRF units work only at the needed rate allowing for substantial energy savings at load conditions. Like traditional central air conditioning systems used for residential and light commercial spaces, VRF systems are air-cooled and refrigerant-based, using outdoor condenser units and indoor fan coil units.

49. What are the differences between Chiller and refrigerator.

Answer: Main difference between chiller and refrigerator:

Chiller	Refrigerator
1. Chiller is something that chills, especially a machine that produces cold air for air conditioning.	1. Refrigerator is a household appliance used for keeping food fresh by refrigeration.
2. Chillers are mostly used in industry.	2. Refrigerators are mostly used in home.

3. Chiller is the machine that extracts heat from liquid by using vapor compression technique to drop the temperature of liquid	3. Refrigerator refrigerates and evaporates which draws the heat from objects and transfers it to the surrounding atmosphere.
4. Chiller temperature range 35 to 45 °F	4. Refrigerator temperature range 35 to 38 °F

50. Difference between FCU and AHU.

Answer:

AHU	FCU
1. AHU is the abbreviation used for Air Handling Unit	1. FCU is the abbreviation used for Fan Coil Unit
2. AHU is a big air handling unit which is used for floor wise	2. FCU is a small air handling unit which is used for small area like rooms , halls etc.
3. It is used to describe any device that handles air that includes devices that transport, heat, or cool it.	3. It refers to a self-contained unit composed of a fan and a heating or cooling heat exchanger.
4. AHU's can have multiple fans.	4. FCU's have only one fan.
5. It has better noise control system.	5. Sometimes it can be noisy.
6. It is generally a bigger and complex system.	6. It is less complex and small system.

51. Why below listed refrigerant are widely used or not used in AC and refrigerator: R-410A, R-22, R-32, R-290, R-134A, R-600A?

Answer: The most common refrigerant in the past was a CFC, most commonly called as Freon. Freon was a brand name for a refrigerant 'R-12' by DuPont. In the 1990s and 2000s, the CFCs were replaced with HCFCs (hydrochlorofluorocarbon) and the most common HCFC is 'R-22'. 50-60% of Air Conditioners in India still (in 2016) use HCFCs. However, HCFCs are just marginally better than CFCs as they contain chlorine, which is harmful for the environment.

To remove chlorine from the refrigerant, manufacturers created another set of refrigerants called HFCs (or Hydro Fluro Carbons). Although they also have the potential for global warming, but still they are better than HCFCs as they do not deplete the ozone layer. The most common HFC used in air conditioners is R-410A. This refrigerant is better than R-22 in terms of "Ozone Depletion" potential and energy efficiency, but it still causes global warming. A few more HFCs that are commonly used are: R-32 in Air Conditioners and R-134A in refrigerators.

Below is the data for Global Warming Potential of various refrigerants (source):

Refrigerant	Global Warming Potential	Ozone Depletion Potential
R-22	1810	Medium
R-410A	2088	Zero
R-32	675	Zero
R-134A	1430	Zero
R-290	3	Zero
R-600A	3	Zero

অধ্যায় ৫

Fluid Mechanics

1. What is fluid mechanics?

Answer: Fluid mechanics is the study of fluids either in motion (fluid dynamics) or at rest (fluid statics). Both gases and liquids are classified as fluids, and the number of fluid engineering applications is enormous: breathing, blood flow, swimming, pumps, fans, turbines, airplanes, ships, rivers, windmills, pipes, missiles, icebergs, engines, filters, jets, and sprinklers.

2. State the Newton's law of viscosity.

Answer: Newton's law of viscosity states that the shear stress between adjacent fluid layers is proportional to the negative value of the velocity gradient between the two layers.

The ratio of shear stress to shear rate is a constant, for a given temperature and pressure, and is defined as the viscosity or coefficient of viscosity.

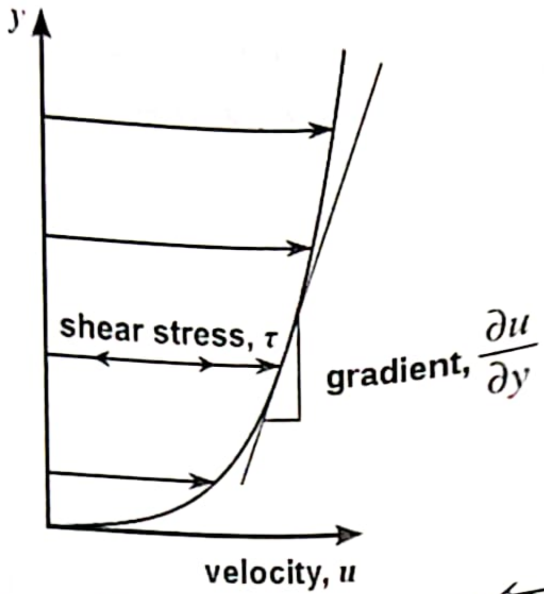
$$\tau \propto -\frac{du}{dy}$$

$$\tau = -\mu\frac{du}{dy}$$

Where, μ = Viscosity,

τ = Shear stress

$\frac{du}{dy}$ = Velocity gradient/ rate of shear deformation



3. **Kinematic Viscosity এবং Dynamic Viscosity এর মধ্যে পার্থক্য কি?**

Answer: Kinematic Viscosity: It is defined as the ratio between the dynamic viscosity and density of fluid.

Dynamic Viscosity:

When two solid bodies in contact, move relative to each other, a friction force develops at the contact surface in the direction opposite to motion. The situation is similar when a fluid moves relative to a solid or when two fluids move relative to each other. The property that represents the internal resistance of a fluid to motion (i.e. fluidity) is called as viscosity. The fluids for which the rate of deformation is proportional to the shear stress are called Newtonian fluids. The shear stress (τ) is then expressed as,

$$\tau = \mu\frac{du}{dy}$$

Where, $\frac{du}{dy}$ is the shear strain rate and μ is the dynamic (or absolute) viscosity of the fluid.

4. **Define different types of Flow.**

Answer: Laminar Flow: Laminar flow is defined as that type of flow in which the fluid particles move along well defined paths or stream line and all the stream lines are straight and parallel.

uniform flow: is that type of flow in which the velocity of flow at a given time does not change with respect to space.
or, for a certain moment, dv/ds =0

Turbulent Flow: Turbulent flow is that type of flow in which the fluid particles move in a zig zag way.

Steady Flow: Steady flow is defined as that type of flow in which the fluid characteristics like viscosity, pressure, density, etc; at a point don't change with time.

Unsteady Flow: Unsteady flow is that type of flow, in which the velocity, pressure or density at a point changes with respect to time.

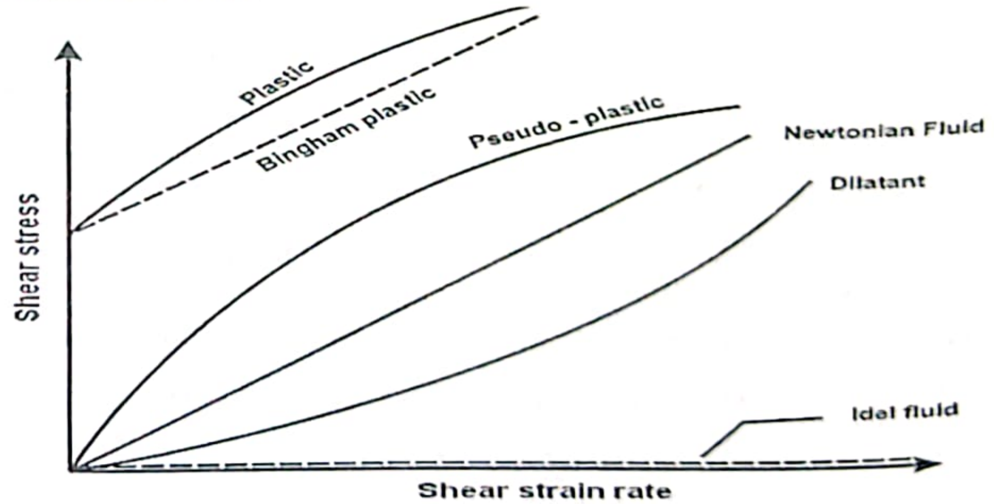
5. What are the types of fluids?

Answer: Real Fluid: A fluid which possesses viscosity is known as real fluid. All fluids, in actual practice, are real fluid.

Ideal Fluid: A fluid, which is incompressible and is having no viscosity, is known as an ideal fluid. Ideal fluid is only an imaginary fluid.

Newtonian Fluid: A real fluid in which the shear stress is directly proportional to the rate of shear strain (velocity gradient) is known as a Newtonian fluid.

Non-Newtonian Fluid: A real fluid in which the shear stress is not proportional to the rate of shear strain is known as Non-Newtonian Fluid.



6. Bernoulli's equation টা লিখ।

Answer: Bernoulli's equation-

$$\frac{p}{\gamma} + \frac{v^2}{2g} + z = \text{constant}$$

Where, p = pressure

v = velocity of fluid
z = datum energy
γ = specific weight = ρg
$\frac{p}{\gamma}$ = pressure energy
$\frac{v^2}{2g}$ = kinetic energy

৭. **Euler's equation টা লিখ।**

$$\frac{dp}{\rho} + g.dx + vdv = 0$$

8. **Pump কয় ধরনের?**

The hydraulic machines which convert the mechanical energy into hydraulic energy are called pumps.

Pumps are in general classified as **Centrifugal Pumps** (or Roto-dynamic pumps) and **Positive Displacement Pumps.**

Centrifugal pumps can be classified further as	The positive displacement pump can be classified as:
• end suction pumps • in-line pumps • double suction pumps • vertical multistage pumps • horizontal multistage pumps • submersible pumps • self-priming pumps • axial-flow pumps • regenerative pumps	• Reciprocating pumps - piston, plunger and diaphragm • Power pumps • Steam pumps • Rotary pumps - gear, lobe, screw, vane, regenerative (peripheral) and progressive cavity

9. **Centrifugal pump কাকে বলে?**

Answer: If the mechanical energy is converted into pressure energy by means of centrifugal force acting on fluid, the hydraulic machine is called centrifugal pump.

The centrifugal pump acts as a reversed of an inward radial flow reaction turbine.

10. **Centrifugal pump এর main part গুলো কি কি?**

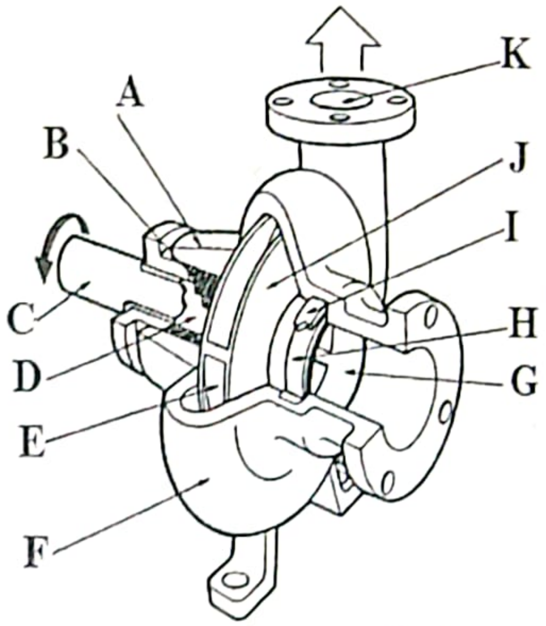
Answer:

(i) Impeller-the rotating part of a centrifugal pump.

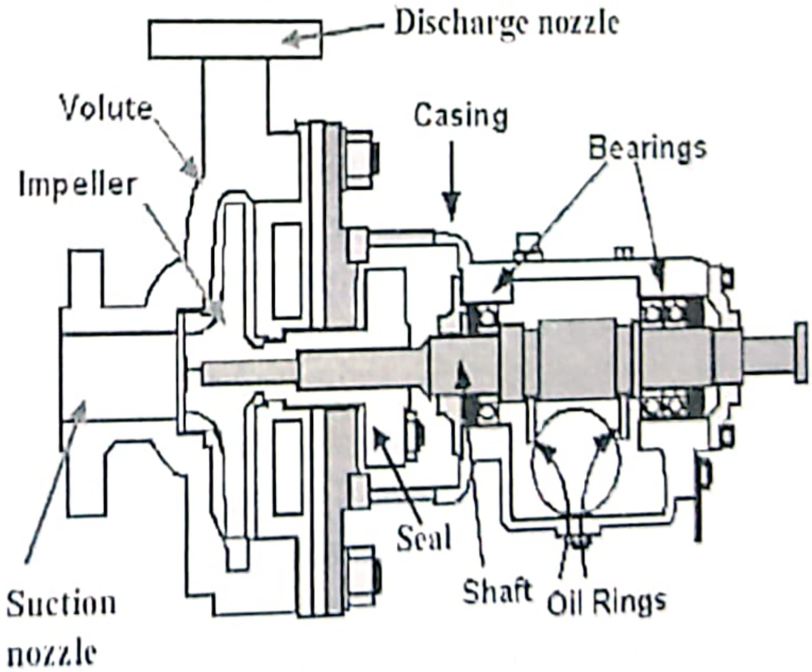
(ii) Casing

(iii) Suction pipe with a foot valve and a strainer

(iv) Delivery pipe
(v) Stuffing box
(vi) Packing/ Seal Ring
(vii) Shaft
(viii) Shaft Sleeve
(ix) Vane
(x) Eye of the Impeller
(xi) Bearing
(xii) Oil Ring



A Stuffing Box
B Packing
C Shaft
D Shaft Sleeve
E Vane
F Casing
G Eye of Impeller
H Impeller
I Casing Wire Ring
J Impeller
K Discharge Nozzle



Centrifugal Pump

11. How does Centrifugal pump work?

Answer: In the volute of the pump fluid enters the pump axially through the eye of the impeller (low pressure area) which rotates at high speed. As the impeller and blades rotate, they transfer momentum to incoming fluid. The fluid accelerates radially outward from the pump chasing and a vacuum is created at the impellers eye that continuously draws more fluid into the pump. As the fluid's velocity increases its kinetic energy increases. Fluid of high kinetic energy is forced out of the impeller area and enters the volute. In the volute the fluid flows through a continuously increasing cross-sectional area, where the kinetic energy is converted into fluid pressure (according the Bernoulli's principle).

The impeller blades are usually backward-curved, but there are also radial and forward-curved blade designs. The output pressure slightly changes according to the design used. The blades may be open or closed. Also the diffuser may be fitted with fixed vanes to help guide the flow toward the exit. The energy transferred to the liquid corresponds to the velocity at the edge of the impeller. The faster the impeller revolves or the bigger the impeller is the higher will the velocity head be.

12. What are the types of casing of a centrifugal pump? What type of casing is mostly used?

Answer: Types of casing- 1) Volute casing, 2) Vortex casing and 3) Casing with guide blades

Among these volute casing is widely used.

13. What are the basic types of Impeller?

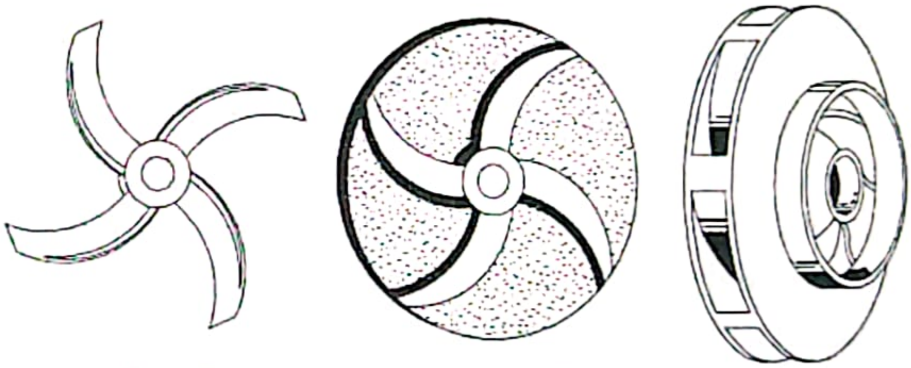
Answer: The impeller of a centrifugal pump can be of three basic types:

Open impeller: Open impellers have the vanes free on both sides. Open impellers are structurally weak. They are typically used in small-diameter, inexpensive pumps and pumps handling suspended solids.

Semi-open impeller: The vanes are free on one side and enclosed on the other. The shroud adds mechanical strength.

They also offer higher efficiencies than open impellers. They can be used in medium-diameter pumps and with liquids containing small amounts of suspended solids. Because of minimization of recirculation and other losses, it is very important that a small clearance exists between the impeller vanes and the casing.

Closed impeller: The vanes are located between the two discs, all in a single casting. They are used in large pumps with high efficiencies and low required Net Positive Suction Head. The centrifugal pumps with closed impeller are the most widely used pumps handling clear liquids. They rely on close-clearance wear rings on the impeller and on the pump casing. The closed impeller is a more complicated and expensive design not only because of the impeller, but the additional wear rings are needed.



open impeller semi-open impeller closed impeller

The impellers The impellers can be-

Backward-curved blade design (prefered design due to negative slope of performance curve)

Radial-blade design

Forward-curved blade design (due to positive slope conditions this design can cause pump surge)

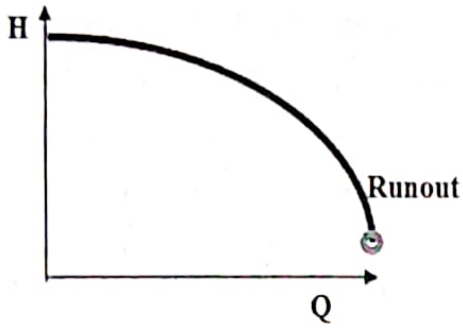
14. What are the types of flow of a centrifugal pump?

Answer: The three types of flow through a centrifugal pump are:

- **radial flow**
- **mixed flow** (part radial, part axial)
- **axial flow** (propeller type)

15. What is run out flow of a centrifugal pump? Why it is so important?

Answer: Pump runout, or runout flow, is the maximum flowrate that can be developed by a pump. The runout conditions correspond to a very small pump head, while the flow rate is maximal.



Importance: Decreasing pressure to and below the runout point may overload the pump motor, which can vibrate and be overheated. Therefore the operation beyond this point should be avoided.

16. Why Series and parallel operation is performed in centrifugal pump?

Answer: Parallel operation of centrifugal pumps is used to increase flow rate through the system. Pumps operating in parallel take their suction from a common header and discharge into a common discharge. While head changes only slightly, flow is almost doubled at any given point.

Series operation of centrifugal pumps is used to overcome large system head loss, or to gain large pressure increase when liquid is injected into very high pressure system. Sometimes it is well known as booster pump system.

17. Multistage centrifugal pump এর function কি?

Answer: A multistage centrifugal pump has two important functions:

1) To produce a high head and 2) To discharge a large quantity of liquid

If high head is to be developed, the impeller are connected in series (or on the same shaft) while for discharging large

quantity of liquid, the impellers (or pumps) are connected in parallel.

18. What is the importance of a minimum flow line of a pump?

Answer: The term minimum flow generally meant the lowest continuous flow at which the pump was permitted to operate.

Operating pumps at below minimum flow can result in the following consequences:

- Pitted/worn impeller vanes
- Overheated casing/bearings
- Excessive noise or vibration
- Broken shafts
- Mechanical seal failures
- Poor performance efficiency

19. What is the function of mechanical seal in a centrifugal pump?

Answer: Mechanical seal in a centrifugal pump is the most effective to prevent leakage from the pump to external surroundings. It basically acts as a check valve which the obvious function is to prevent liquid under pressure from leaking out of the pump or drawing air into the pump when the pump is operated under vacuum condition.

It forms a packing between the rotor and the stationary part of centrifugal pump to prevent the leakage of the liquid being pumped. There are two basic parts of seals; one is stationary part, which is connected to pump housing and the other is rotating part which is connected to rotating shaft of the pump.

20. What is the function of coupling and bearing in a centrifugal pump?

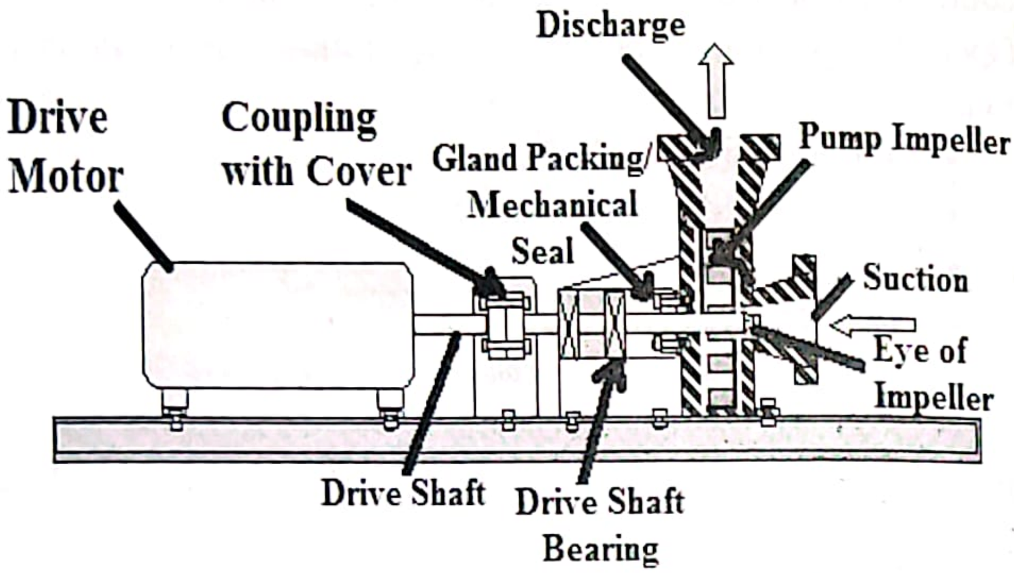
Answer: The function of couplings are to connect the pump shaft and the driver shaft, and to transmit the input power from the driver into the pump.

The function of the bearing is to support the weight of the shaft (rotor) assembly, to carry the hydraulic loads acting on the

shaft, and to keep the pump shaft aligned to the shaft of the driver.

21. What is the overhaul procedure of a single stage horizontal centrifugal pump?

Answer:



1. Switch off the breaker and take out the fuse (or rack out if necessary) and keep it in a safe place. Make sure the LOTO (Lock out Tag out).
2. Close suction and discharge valve.
3. If there is suction or discharge pipe drain valve then open it and escape the water.
4. Remove the electrical connection of the motor and mark the connections appropriately.
5. Remove suction and discharge pipe flange bolt & nut, coupling bolt of motor coupling.
6. Remove impeller lock & nut & take out the impeller
7. Remove mechanical seal.
8. Remove bearing cover from other side & take out shaft with ball bearing
9. Renew mechanical seal and bearings if required.
10. Clean and inspect all parts and assemble.

22. What is alignment of a centrifugal pump?

Answer: Long-coupled pumps have separate pump and motor shafts that are connected through a coupler. Ideally these two

shafts will be exactly parallel and have exactly the same centre-line. Flexible couplers can tolerate small alignment errors, but for smooth, trouble-free running, it is important to ensure that these two shafts are lined upto the tolerances specified by the pump, motor and coupler manufacturers.

23. কখন **centrifugal pump** ব্যবহার করা হয় আর কখন **Positive Displacement Pump** ব্যবহার করা হয়।

Answer: Centrifugal pump is used for deliverying high flow and positive displacement pump is used for developing high head. On the other hand, positive displacement pump handles high viscous fluid and centrifugal pump handles low viscous fluid. যেমনঃ HFO (Heavy Fuel Oil-crude oil) based power plant এ HFO transfer এর জন্য Positive Displacement Pump (Screw) ব্যবহৃত হয়। আবার water treatment plant -এ chemical dosing এর জন্য Positive Displacement Pump (Diaphram type) ব্যবহৃত হয়। Food Industry গুলোতে pulp transfer এর জন্য Positive Displacement Pump (Screw) ব্যবহৃত হয়।

উপরের সবগুলো ক্ষেত্রে Positive Displacement Pump ব্যবহার করা হয় কারণ এসব ক্ষেত্রে high viscous fluid পাম্প করা হচ্ছে।

24. Net positive suction head কাকে বলে?

Answer: Net positive suction head (NPSH) is defined as the difference between the pump's inlet stagnation pressure head and the vapor pressure head. Or, the net positive suction head (NPSH) is defined as the difference between the net inlet head and the head corresponding to the vapour pressure of the liquid.

$$NPSH = \left(\frac{P}{\rho g} + \frac{V^2}{2g}\right)_{\text{pump inlet}} - \frac{P_v}{\rho g}$$

We may think of NPSH as the actual or available net positive suction head.

On the other hand, required net positive suction head (NPSH required) is defined as the minimum NPSH necessary to avoid cavitation in the pump. As long as the actual NPSH is greater than NPSH required, there should be no cavitation in the pump.

25. Centrifugal pump এ Priming করা হয় কেন?

Answer:

Priming of a centrifugal pump is defined as the operation in which the suction pipe, casing of the pump and a portion of the delivery pipe upto the delivery valve is completely filled up from outside source with the liquid to be raised by the pump before starting the pump. Thus, the air from these parts of the pump is removed and these parts are filled with the liquid to be pumped. When the pump is running in air, the head generated is in terms of metre of air. If the pump is primed with water, the head generated is same metre of water. But as the density of air is very low, the generated head of air in terms of equivalent metre of water head is negligible and hence the water may not be sucked from the pump. To avoid this difficulty, priming is necessary.

26. Cavitation কেন হয়?

Answer: Cavitation is defined as the phenomenon of formation of vapor bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapor pressure and the sudden collapsing of these vapor bubbles in a region of high pressure. When the vapor bubbles collapse, a very high pressure is created. The metallic surface, above which the liquid is flowing, is subjected to these high pressures, which cause pitting action on the surface. Thus cavities are formed on the metallic surface and also considerable noise and vibrations are produced.

27. Cavitation রোধে কি করা উচিত?

Answer: The following precautions should be taken against cavitation:

i) The pressure of the flowing liquid in any part of the hydraulic system should not be allowed to fall below its vapor pressure. If the flowing liquid is water, then the absolute pressure head should not be below 2.5m of water.

ii) The special materials or coatings such as aluminium-bronze and ss (Stainless Steel), which are cavitation resistant materials, should be used.

Effects of cavitation: the following effects of cavitation:

i) The metallic surfaces are damaged and cavities are formed on the surfaces.

ii) Due to sudden collapse of vapor bubble, considerable noise and vibrations are produced.

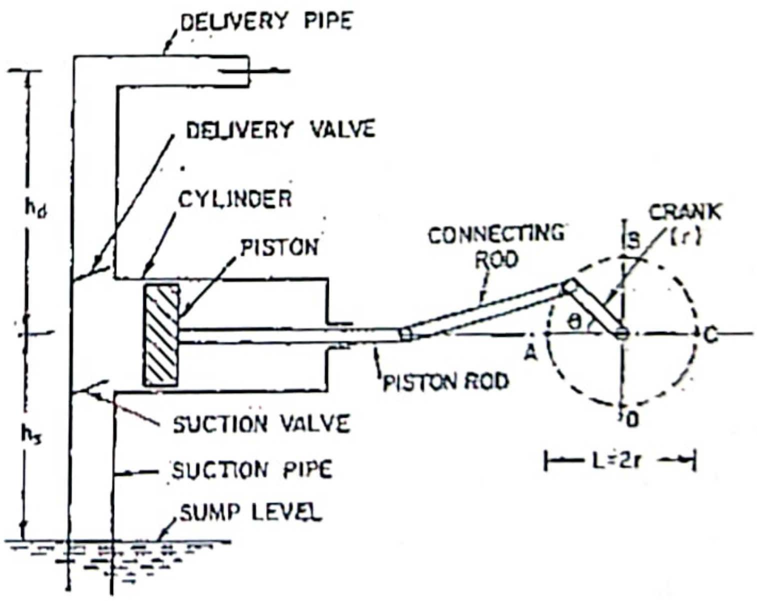
iii) The efficiency of a turbine decreases due to cavitation. The work done by water or output horse power becomes less and thus efficiency decreases.

28. Reciprocating pump কাকে বলে?

Answer: If the mechanical energy is converted into hydraulic energy (or pressure energy) by sucking the liquid into a cylinder in which a piston is reciprocating (moving backwards and forwards), which exerts the thrust on the liquid and increases its hydraulic energy (pressure energy), the pump is known as reciprocating pump.

Main parts of reciprocating pump:

1. A cylinder with a piston, piston rod, connecting rod and a crank, 2. Suction pipe 3. Delivery pipe 4. Suction valve and delivery valve.



29. Reciprocating pump এর Slip কাকে বলে?

Answer: Slip of a pump is defined as the difference between the theoretical discharge and actual discharge of the pump. The actual discharge of a pump is less than the theoretical discharge due to leakage.

Mathematically, slip= $Q_{th} - Q_{act}$

Percentage of slip $= \frac{Q_{th}-Q_{act}}{Q_{th}} \times 100\%$

$= (1 - c_d) \times 100\%$

where C_d is Co-efficient of discharge.

30. Reciprocating pump এর Negative slip কাকে বলে?

Answer: Slip is equal to the difference of theoretical discharge and actual discharge of the pump. If actual discharge is more than the theoretical discharge, the slip of the pump will become negative.

In that case, the slip of the pump is known as negative slip. Negative slip occurs when delivery pipe is short, suction pipe is long and pump is running at high speed.

31. Separation কাকে বলে?

Answer: If cylinder pressure is less than the vapor pressure of liquid then the dissolved gases liberated from the liquid and cavitation takes place. As a result continuous flow of liquid does not exist and it is called separation.

32. Why cavitation will occur in centrifugal pumps and not in displacement pump?

Answer: Cavitation is production of vapor phase of liquid when the pressure within the flow goes so low it approaches vapor pressure.

So, it is 'boiling' of liquid due to immense pressure drop rather than heat addition considering the mechanism of formation, cavitation cannot happen just by low pressure (although that is a necessary condition). Inception of cavitation in a multi-component liquid at pressures near vapor pressure requires presence of nuclei which contain vapor, air or both. Cavitation occurs when these nuclei become unstable and aid to sudden localized flow instability. Since centrifugal pumps operation is

based on use of hydrofoils, this phenomenon of unstable nuclei happens in this case only.

The major instability in centrifugal pumps can be due to one of the following causes:

- Too high flow velocity for a given geometry leading to extreme turbulence over hydrofoil
- Sharp edge hydrofoil (used to reduce drag but leads to early cavitation)
-Turbulent shear flow (flow itself turbulent)
- Other special cases like water entry cavity and bubble chambers.

No doubt, positive displacement pumps do have nuclei but they are stable. And there stability is not aggravated since no such events occur in positive displacement pumps.

33. What is the function of orifice meter, venturimeter, manometer and pitot tube?

Answer: Orifice meter: It is a device used for measuring the rate of flow of fluid through a pipe. It is a cheaper device compared to venturimeter. It consists of a flat circular plate which has a circular sharp edged hole called orifice through it may vary from 0.4 to 0.8 times the pipe diameter.

Venturimeter: A venturimeter is a device used for measuring the rate of flow of fluid flowing through a pipe. It is based on the principle of Bernoulli's equation. It consists of three parts:

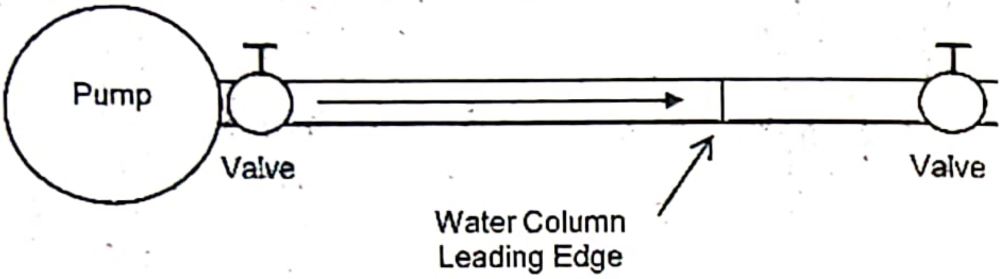
i. A short converging part
ii. Throat and
iii. Diverging part

Pitot tube: It is a device for measuring the velocity of flow at any point in a pipe or a channel. It is based on the principle that if the velocity of a flow at point becomes zero, the pressure there is increased due to the conversion of the kinetic energy. It consists of a glass tube bent at right angles

34. Water Hammer কি?

Answer: When a liquid is flowing through a long pipe fitted with a valve at the end of the pipe and the valve is closed

suddenly a pressure wave of high intensity is produced behind the valve. This pressure wave of high intensity is having the effect of hammering action on the walls of pipe. This phenomenon is known as water hammer.



The pressure rise due to water hammer depends upon: (i) the velocity of flow of water in pipe, (ii) the length of pipe, (ii) time taken to close the valve, (iii) Elastic properties of the material of the pipe. The following cases of water hammer in pipes will be considered:

1. Gradual closure of valve,
2. Sudden closure of valve and considering pipe rigid, and
3. Sudden closure of valve and considering pipe elastic.

35. বিভিন্ন ধরনের Valves এর বর্ণণা দাও।

Answer: Valves isolate, switch, and control fluid flow in piping systems. Can be operated manually (using levers or gear operators) or remotely (using electric, pneumatic, electro-pneumatic and electro-hydraulic powered actuators). Manual valves are usually used only if they will be operated infrequently or no power source is available.

Basic Valve Types

Isolation valves: On/off valves typically operated as fully open or fully closed and designed to have a tight reliable seal during shut-off and minimal flow restriction when open. Such as: Ball valve, butterfly valve, diaphragm valve, floats valve, gate valve, globe valve and solenoid valve.

Switching valves: Converge or divert flow in a piping system.

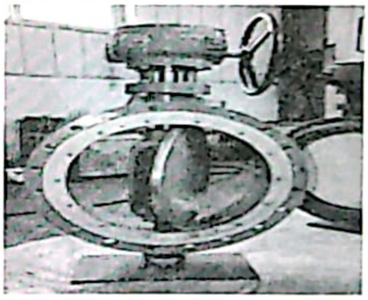
Control valves: Used to modulate flow (i.e., vary flow by opening or closing by a certain percentage)

Isolation Valves

Ball valve: A ball with a hole through one diameter that can be rotated to align with the flow or block it. They provide quick, tight shutoff, high capacity, and require only a ¼ turn to operate. It can be actuated with pneumatic and electric actuators.



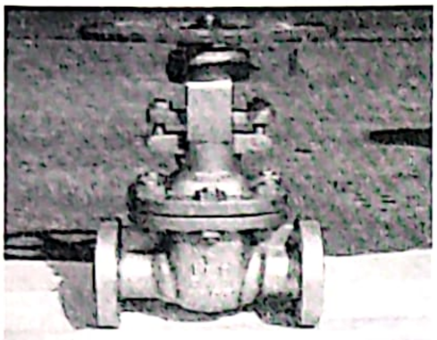
Butterfly valve: Can be used for both general and severe applications. Liners help to provide tight shut-off. The most economical valves per comparable capacity and easily actuated with pneumatic and electric actuators.



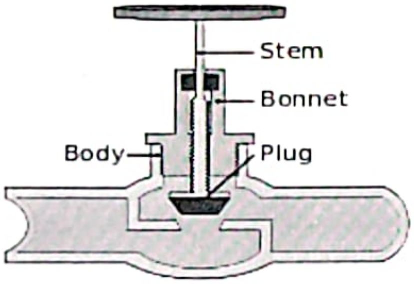
Diaphragm valves: It is very simple. Plunger and hand wheel often used to apply pressure to diaphragm to form seal; may be actuated pneumatically and electrically, often used for corrosive, slurry, and sanitary services.

Float valves: It controls liquid level and prevent tank overfilling. Operated mechanically by a float that rests on top of the liquid; as the level rises, it pushes the float up and closes the valve.

Gate valves: A sliding disk slides up and down in and out of the fluid. Good for high pressure drop and high temperature applications where operation is infrequent. Manual operation or else multi-turn electric actuators are most common.



Globe valves: A conical plug moves in and out of the fluid. It can be used for shutoff as well as throttling (flow restriction to cause a drop in pressure) in high pressure drop and temperature applications available in globe, angle, and y-patterns. Manual operation or else multi-turn electric actuators are most common. Easier to repair but more pressure drop than a gate or plug valve.



Solenoid valve: Electrically operated .Valve plug is held in place by a spring. When power is applied, the current draw through the coil generates an electromagnetic force that opposes the spring and changes the plug position. When power is taken away, the spring returns the plug to its normal position.

Switching Valves: Converge and divert flow in a piping system. Usually 3-way valves used because they can take the place of 2-way valves 3-way valves are usually ball, plug, or globe design 2 butterfly valves mounted on a pipe tee will also work and is cost-effective for large pipes.

Control valves: Valves listed earlier can be used to modulate flow, but some work better than others Diaphragm valves work well to throttle flow. Proportional solenoid valves are economical. Reciprocating globe valves, are rugged, expensive, and very accurate (<2% accuracy). They can be noisy. Rotary globe valves are similar to reciprocating but with more

capacity and greater possible turndown. Low cost and good accuracy makes them a common choice for flow control.

Other valve types: Many other valve types are out there to fit specific applications. For example:

Steam traps

Pressure-relief valves

Capillary tubes

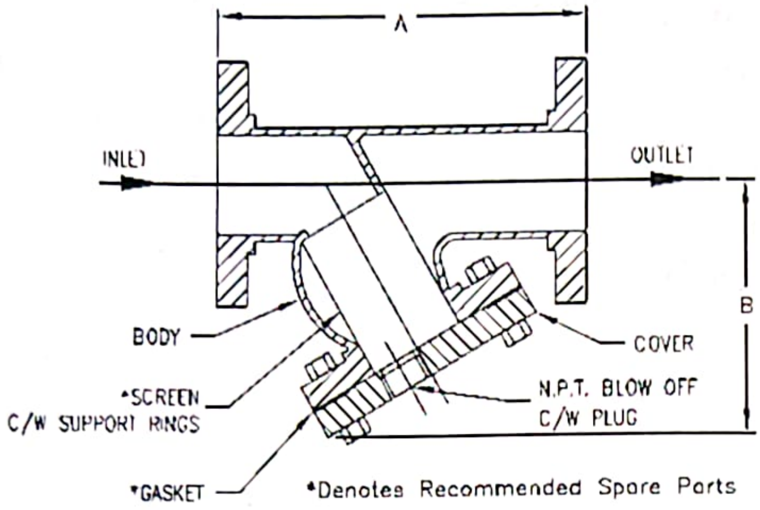
Thermostatic expansion valve

24. বিভিন্ন ধরনের **Strainers or Filters** এর বর্ণণা দাও।

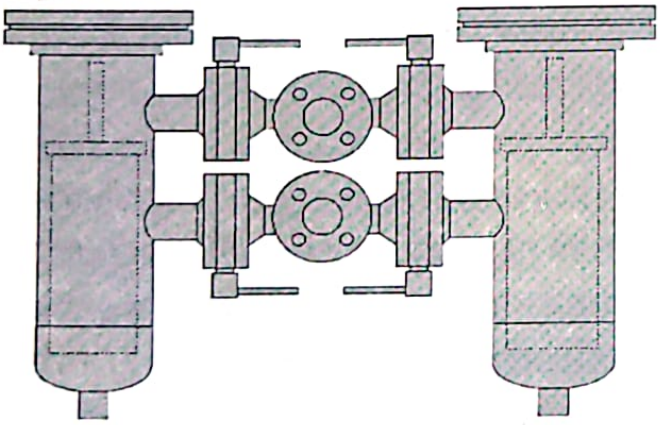
Answer: Strainers or filters are devices used for separating solid from liquids and catching dirt and debris. They act as a filter trapping large particles. By doing so, the particles would not continue to the system and will have expensive pipeline equipment such as pumps, engines, valves, heat exchangers, nozzles and others protected from harmful flow contamination. There are three types of strainers-

1. Y- Type strainer
2. Duplex-basket type
3. T-Type strainer

Y-strainer: The most common type of strainers is Y-strainer. Its name is derived from its y-shaped form. This type is commonly used in pressurized lines, steam, liquid or gas, but can also be applied in vacuum or suction situation. It has low resistance to fluid passage or straight passage which in turn results to low pressure loss. This is why y-strainers are being utilized for applications where only small amounts of solid particulates are expected to be drained and frequent clean out would not be necessary.

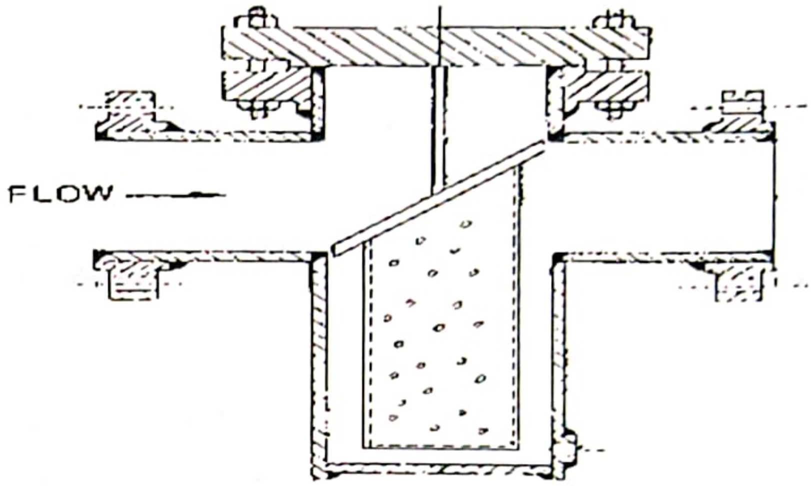


Duplex basket-type strainer: Duplex basket-type strainer is more suitable for robust chemical and abrasive applications. It is designed so no interruption on the process would happen to give way to cleaning of the strainer. It does this by altering the flow of the fluid to a second strainer once it detected the first basket is full. This way, the operator is allowed to remove the strainer, clear the particles in it and put it back without disrupting the process.

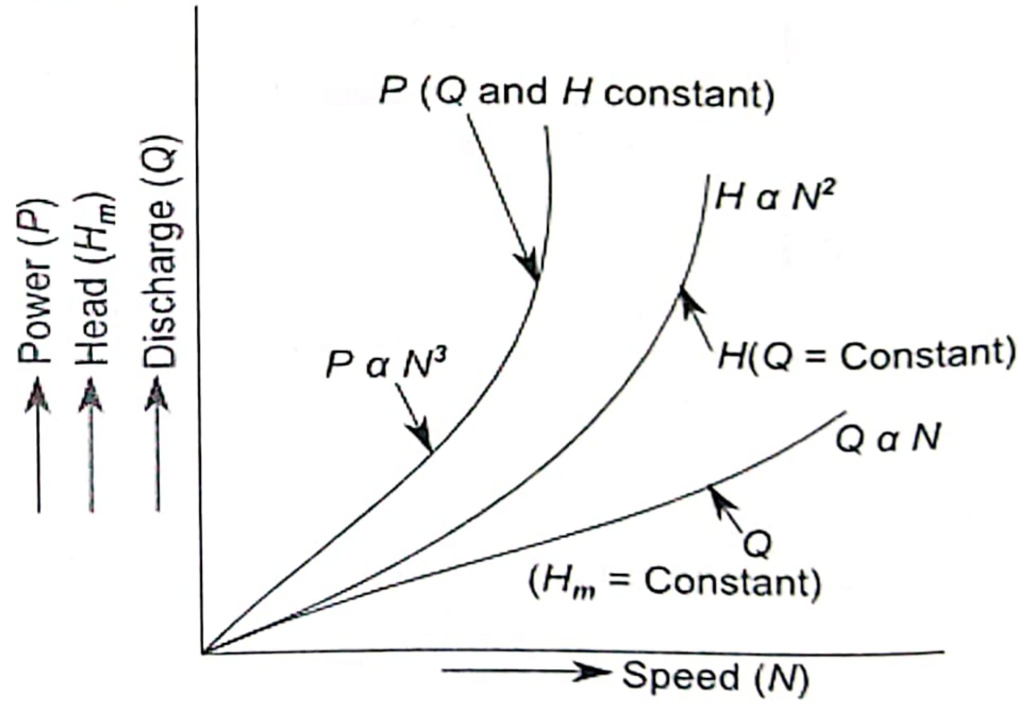


T-type basket strainer: T-type basket strainers are most appropriate to use in pipeline systems. To increase efficiency, ensure leak tightness and achieve utmost protection of control valves, it is recommended to install the strainer first before the shut-off control valves. This way, dirt particles will be prevented from entering and reaching the main shut-off valve and control valves. Some of the common installations of basket-type strainers include chemical processing, food and

beverage, waste and water treatment, pulp and paper, pharmaceutical, agriculture, aquatics, water parks and marine.

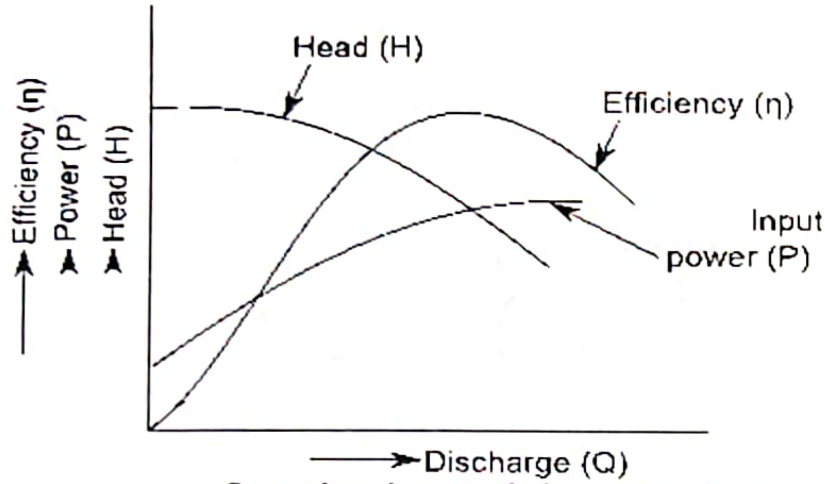


25. Centrifugal pump এর ক্ষেত্রে Main characteristics curve আঁক।



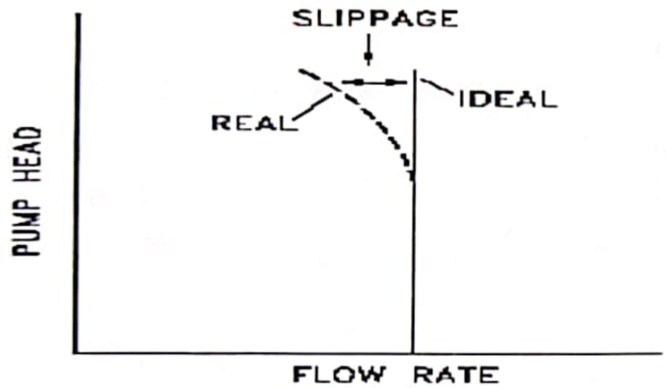
Main characteristics curves of a pump.

26. Centrifugal pump এর ক্ষেত্রে Operation characteristics curve আঁক।



Operating characteristics curve of pump

27. Positive displacement pump এর ক্ষেত্রে Operation Characteristics Curve আঁক।



28. What is center of buoyancy?

Answer: Center of buoyancy is the center of gravity of the displaced liquid and buoyant force acts through it.

29. Centrifugal pump কে high discharge pump বলা হয় কেন?

Answer: A centrifugal pump uses the centrifugal force to push out the fluid. Therefore, the liquid entering the pump receives kinetic energy from the rotating impeller. The centrifugal action of the impeller accelerates the liquid to a high velocity, transferring mechanical (rotational) energy to the liquid. So it discharges the liquid in high rate. It is given in the following formula:

Centrifugal force $F = (mv^2)/r$.

Where, m-Mass, v-Velocity, r-Radius

অধ্যায় ৬

Heat Transfer

1. What are the different modes of heat transfer?

Answer: Conduction: Conduction is the transfer of heat from one part of a substance to another part of the same substance or from one substance to another in physical contact with it, without appreciable displacement of molecules forming the substance.

Convection: Convection is the transfer of heat within a fluid by mixing of one portion of the fluid with another.

Radiation: Radiation is the transfer of heat through space or matter by means other than conduction or convection.

2. What is the Fourier's law of conduction?

Answer: The rate of flow of heat through a simple homogeneous solid is directly proportional to the area of the section at right angles to the direction of heat flow and to change of temperature with respect to the length of the path of the heat flow.

the rate of HT is directly proportional to the area normal to the heat flow and temperature gradient

Mathematically,

$$Q = -kA\frac{dT}{dx}$$

Where,

Q =the heat flow rate by conduction (W)

k=the thermal conductivity of body material ($W \cdot m^{-1} \cdot K^{-1}$)

A=the cross-sectional area normal to direction of heat flow (m^2) and

$\frac{dT}{dx}$ = the temperature gradient ($K \cdot m^{-1}$).

–(ve) sign in Fourier's equation indicates that the heat flow is in the direction of negative gradient temperature and that serves to make heat flow positive.

3. What is thermal conductivity?

Answer: Thermal conductivity of a material is numerically equal to the quantity of heat (in joules) which flows in one second through a slab of the material of area $1m^2$ and thickness 1m when its faces differ in temperature by 1K.

$$Q = KA\frac{T_1 - T_2}{x}$$

In this equation, if we substitute $A=1m^2$; $T_1 - T_2 = 1K$; and $x=1m$, then $Q=k$.

K= Thermal conductivity.

4. Different types of fluid forces and some dimensionless Numbers:

Types of force present in moving fluid:

(a) **Inertia Force:** product of mass and acceleration of the flowing fluid.

(b) **Viscous Force:** Product of shear stress due to viscosity and cross sectional area of flow.

(c) **Gravity Force:** Product of mass and acceleration due to gravity of fluid.

(d) **Surface Tension Force:** Product of surface tension per unit length and length of the surface of flowing liquid.

(e) **Pressure Force:** Product of intensity of pressure and area of flowing fluid.

(f) **Elastic Force:** Product of elastic stress and area of the flowing liquid.

(g) **Head:** Head is a concept that relates the energy in an incompressible fluid height of an equivalent static column of that fluid.

Reynolds Number: It is defined as the ratio of the inertia force to the viscous force. i.e.,

Re = Inertia Force/Viscous Force= $\rho VD/\mu = VD/\vartheta$

Significance:

- Reynolds number signifies the relative predominance of the inertia to the viscous forces occurring in the flow systems.
- Higher the Reynolds number, greater will be the relative contribution of inertia effect. Smaller the value of Re, greater will be the relative magnitude of the viscous stresses.
- Reynolds number is taken as an important criterion of kinematic and dynamic similarities in forced convection heat transfer.
- It indicates that the flow is laminar or turbulent. For pipe flow if $Re < 2000$, the flow is laminar, if $Re > 4000$, the flow is turbulent. If $4000 < Re < 2000$ it is in transition. For flat plate in case of laminar flow $Re < 50{,}000$ and in case of turbulent, Re is between 50,000 to 100,000.

Prandtl Number (Pr): It is the ratio of kinematic viscosity (ϑ) to the thermal diffusivity (α). i.e.,

$$Pr = \vartheta / \alpha$$

Kinematic viscosity indicates the impulse transport through molecular friction whereas thermal diffusivity indicates the heat energy transport by conduction process.

Significance:

- Prandtl number provides a measure of the relative effectiveness of the momentum and energy transport by diffusion.
- Prandtl number is a connecting link between velocity field and temperature field.

Nusselt Number (Nu): It is the ratio of heat flow rate by convection process under a unit temperature gradient to the heat flow rate by conduction process under a unit temperature gradient through a stationary thickness of L meters. i.e.

$Nu = hL/K$

Significance:

- The Nusselt number represents the enhancement of heat transfer through a fluid layer as a result of convection relative to conduction across the same fluid layer.
- The larger the Nusselt number, the more effective the convection.
- A Nusselt number of Nu = 1 for a fluid layer represents heat transfer across the layer by pure conduction.

Stanton Number: It is the ratio of heat transfer coefficient to the flow of heat per unit temperature residue of the velocity of fluid.

It also defined as-

St= Nu/(Re.Pr)

So, it is the ratio of Nusselt number and the product of Reynolds number and Prandtl number.

Peclet Number: It is the ratio of mass heat flow rate by convection to the flow rate by conduction under a unit temperature gradient and through a thickness L.

It also defined as – Pe = Re.Pr

Graetz Number: It is defined as the ratio of heat capacity of fluid flowing through the pipe per unit length of the pipe to the conductivity of pipe. i.e.

G= mCp/ LK

Grashof Number: Gr = (Inertia Force ×Buoyancy Force)/ $(\text{Viscous Force})^2$

Froude Number: The Froude number is a dimensionless number defined as the ratio of a characteristic velocity to a gravitational wave velocity. It may equivalently be defined as the ratio of a body's inertia to gravitational forces. In fluid mechanics, the Froude number is used to determine the resistance of an object moving through water, and permits the comparison of objects of different sizes. Named after William Froude, the Froude number is based on the speed/length ratio as defined by him.

The Froude number is defined as: $\mathrm{Fr} = \frac{V}{C}$

Where, V is a characteristic velocity , and C is a characteristic water wave propagation velocity. The Froude number is thus analogous to the Mach number. The greater the Froude number, the greater the resistance.

Weber Number=Inertia Force/ Surface Tension Force

Euler's Number=Inertia Force/Pressure Force

Mach's Number (M) = $\sqrt{(\frac{\text{Inertia Force}}{\text{Elastic Froce}})}$ = Velocity of fluid or body moving in fluid / Velocity of sound in the fluid = V/C

Significance: (a) When M<1 then, Flow is called sub-sonic.
(b) When M=1 then, Flow is called sonic.
(c) When 6>M>1 then, Flow is called super-sonic.
(d) When M>6 then, Flow is called hypersonic.

5. Heat exchanger কত প্রকার?

1. Nature of heat exchange process:

i. Direct contact heat exchangers. (Ex: Cooling towers, Jet condensers, direct contact feed heaters)

ii. Indirect contact heat exchangers

a. Regenerators. (Ex: I.C engines and gas turbines, Open hearth and glass melting furnaces, Air heaters of blast furnaces)

b. Recuperators. (Ex: 1. Auto mobile radiators, 2. Oil coolers, intercoolers, air preheaters, economizers, Superheater, 3. Milk chiller of pasteurizing plant 4. Evaporator of an ice plant)

2. Relative Direction of fluid motion:

i. Parallel flow or unidirectional flow. (Ex: Oil coolers, Oil heaters, water heaters)

ii. Counter-flow.

iii. Cross Flow.(Ex: The cooling unit of refrigeration system)

3. Design and construction features

i. Concentric tubes

ii. Shell and tube

iii. Multi shell and tube passes

iv. Compact heat exchangers (Ex: Plate fin, Flattened fin tube exchangers)

4. Physical state of fluid

i. Condensers and ii. Evaporators

6. LMTD কাকে বলে?

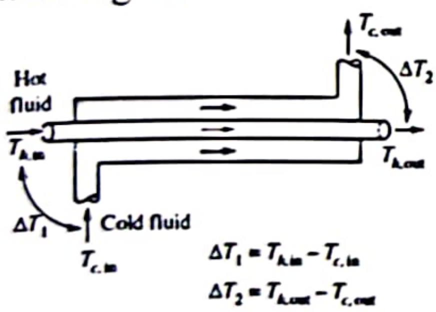
Answer: Logarithmic mean temperature difference (LMTD) is defined as that temperature difference which, if constant, would give the same rate of heat transfer as actually occurs under variable conditions of temperature difference. The larger the value of LMTD, the higher heat is transferred. The rate of heat transfer can be expressed as

$$q = UA\Delta T_m$$

Where ΔT_m is the logarithomic mean temperature difference given as

$$\Delta T_m = \frac{\Delta T_1 - \Delta T_2}{\ln \frac{\Delta T_1}{\Delta T_2}}$$

Parallel flow Heat exchangers:

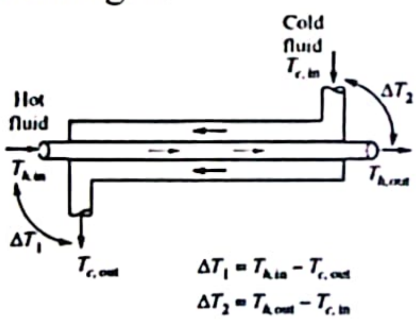


Parallel Flow Heat Exchanger

$\Delta T_1 = T_{hot,in} - T_{cold,in}$

$\Delta T_2 = T_{hot,out} - T_{cold,out}$

Counter flow heat exchanger:

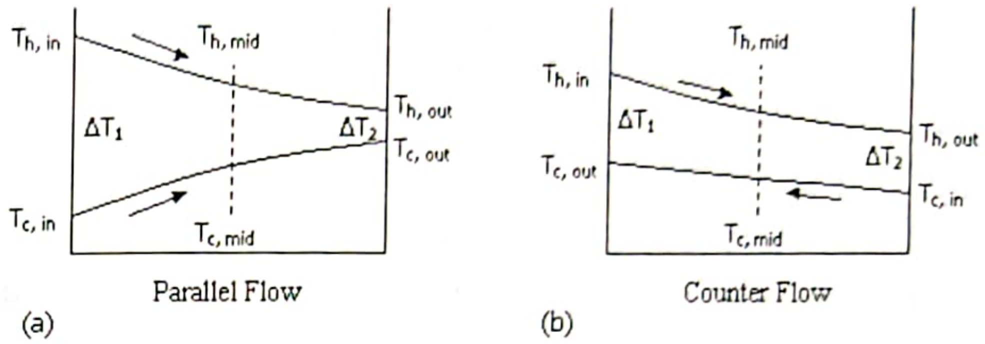


Counter Flow Heat Exchanger

$\Delta T_1 = T_{hot,in} - T_{cold,out}$

$\Delta T_2 = T_{hot,out} - T_{cold,in}$

Temperature Profile:



7. Critical Thickness কাকে বলে?

Answer: The thickness up to which heat flow increases and after which heat flow decreases is known as critical thickness. In case of cylinder and sphere it is called critical radius.

8. Fouling Factor কাকে বলে?

Answer: During operation of the heat and mass carrying, tube surface gets covered by deposits of ash, soot, dirt and scale etc. This phenomenon of rust formation and deposition of fluid impurities is called fouling. It is difficult to ascertain the thickness and thermal conductivity of scale deposits, the effect of scale on heat flow is considered by specifying an equivalent scale heat transfer coefficient h_s. The reciprocal of heat transfer coefficient h_s is called the fouling factor, R_f.

$$R_f = \frac{1}{h_s} = \frac{1}{U_{dirt}} - \frac{1}{U_{clean}}$$

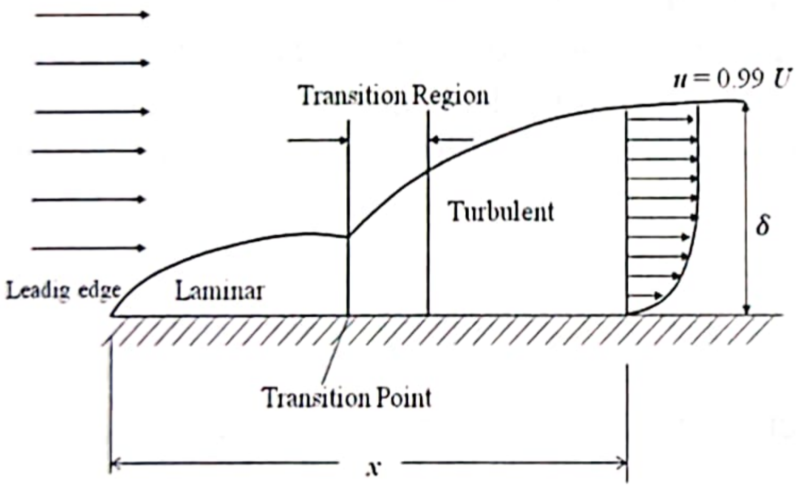
9. Boundary Layer কাকে বলে?

Answer: When a real fluid flows past a stationary solid boundary, a layer of fluid which comes in contact with the boundary surface adheres to it and condition of no slip occurs. Thus the layer of fluid which can't slip away from the boundary surface undergoes retardation, this retarded layer further causes retardation for the adjacent layers of the fluid, thereby developing a small region in the immediate vicinity of the boundary surface and approaches the velocity of main stream. The layer adjacent to the boundary is known as boundary layer.

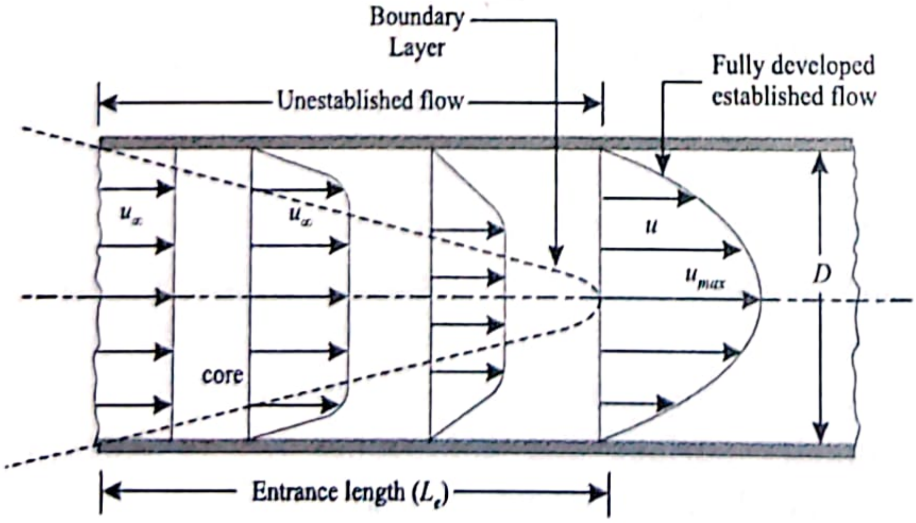
10. Boundary layer thickness কাকে বলে?

Answer: The boundary layer thickness is defined as the distance from the surface to a point where the velocity reaches 99% of the free stream velocity. Thus, the velocity profile merges smoothly and asymptotically into the free stream. It is known that in order to achieve no-slip conditions at the solid surface, the fluid must attain the zero velocity at the wall. Subsequently, above the wall, the effect of viscosity tends to reduce and the fluid within this layer will try to approach the free stream velocity. Thus, there is a velocity gradient that develops within the fluid layers inside the small regions near to solid surface.

11. Draw a Boundary Layer Profile for Flat Plate.



12. Draw a laminar velocity profile in the intake region of a tube.



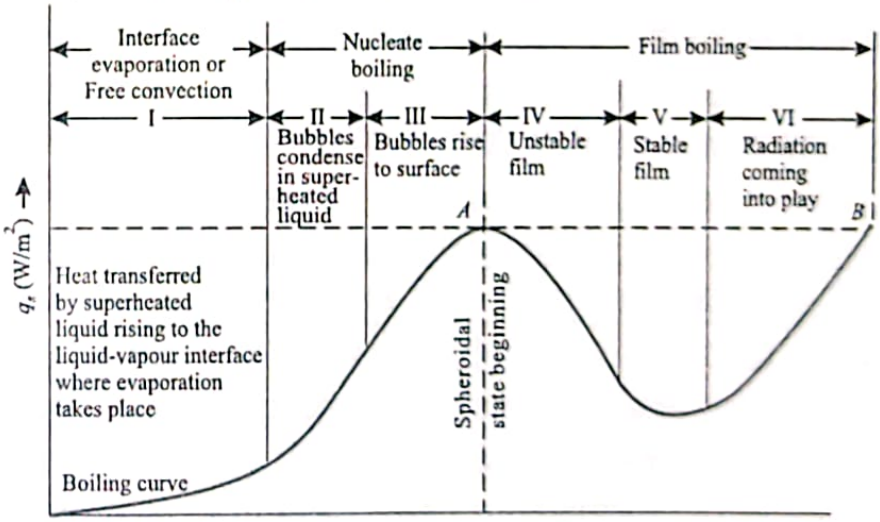
The development of a laminar velocity profile in the intake region of a tube.

13. What is the difference between boiling and evaporation?

Answer: Boiling is a liquid-to-vapor phase change process just like evaporation, but there are significant differences between the two. Evaporation occurs at the liquid–vapor interface when the vapor pressure is less than the saturation pressure of the liquid at a given temperature. Water in a lake at 20°C, for example, will evaporate to air at 20°C and 60 percent relative humidity since the saturation pressure of water at 20°C is 2.3 kPa and the vapor pressure of air at 20°C and 60 percent relative humidity is 1.4 kPa.

Boiling, on the other hand, occurs at the solid–liquid interface when a liquid is brought into contact with a surface maintained at a temperature T_s (Surface temperature) sufficiently above the saturation temperature T_{sat} of the liquid. At 1 atm, for example, liquid water in contact with a solid surface at 110°C will boil since the saturation temperature of water at 1 atm is 100°C.

14. Draw a boiling Curve for water.



The boiling curve for water.

Description:

1. Interface Evaporation: Interface evaporation (evaporation process with no bubble formation) exists in region I, called the free convection zone. Here the excess temperature, Δt_e is very small and ≈ 5°C. In this region the liquid near the surface is

superheated slightly, the convection currents circulate the liquid and evaporation takes place at the liquid surface.

2. Nucleate Boiling: This type of boiling exists in regions II and III. With the increase in Δt_e(excess temperature) the formation of bubbles on the surface of the wire at certain localized spots commences. The bubbles condense in the liquid without reaching the liquid surface. In fact, it is the region II where nucleate boiling starts. With further increase in Δt_e the bubbles are formed more rapidly and rise to the surface of the liquid resulting in rapid evaporation, as indicated in the region III.

3. Flim Boiling: Flim boiling comprises of regions IV, V and VI. The trend of increase of heat flux with increase in excess temperature observed upto region III is reversed in region IV (called flim boiling region). This is due to the fact that the bubble formation is very rapid and the bubbles blanket the heating surface and prevent the incoming fresh liquid from taking their place. Eventually the bubbles coalesce and form a vapour flim which covers the surface completely. Since the thermal conductivity of vapour flim is much less than that of the liquid the heat flux drops with growth in Δt_e. With in the temperature range 50°C<Δt_e<150°C, conditions oscillate between nucleate and flim boiling and the phase is reffered to as transition boiling, unstable flim boiling or partial flim boiling (region IV).

অধ্যায় ৭

Power Plant Engineering

1. Renewable Energy এবং Non-Renewable Energy এর মধ্যে পার্থক্য কি?

Answer:

Renewable energy is energy which is generated from natural sources i.e. sun, wind, rain, tides and can be generated again and again when required.

Non-renewable energy is energy which is taken from the sources that are available on the earth in limited quantity and will vanish fifty-sixty years from now. Non-renewable sources are not environmental friendly and can have serious affect on our health.

2. Conventional এবং Non-conventional energy source এর মধ্যে পার্থক্য কি?

Answer:

Conventional Sources	Non-conventional Sources
Conventional sources of energy (coal, petroleum and natural gas) are non-renewable sources of energy.	Non-conventional sources of energy (e.g. solar and wind energy) are renewable sources of energy.

They have been in use since a long time. For example, firewood and coal have been in use since a long time.	These sources have recently developed and are still developing. For example, the technology of producing electricity from solar panels has recently developed.
Most of these energy sources (e.g. coal and firewood) cause pollution when used.	They do not cause any pollution (e.g. solar energy, geothermal energy etc.)
They are common and widely used sources (e.g. thermal power).	They are comparatively new sources of energy and hence are not widely used. For example, solar panels and wind mills are not widely used.

For Details: The sources of energy used for mass generation off power called conventional sources of energy are as follows:

i. Thermal ii. Hydro-Power iii. Nuclear Power

The energy sources which cannot be compensated, once these are used (after their exploitation) are termed as conventional energy sources.

Some important conventional energy sources are discussed below:

Coal: Coal is a major conventional energy sources. It was formed from the remains of the trees and ferns grew in swamps around 500 million year ago. The bacterial and chemical decomposition of such plant debris (which remained buried under water or clay) produced an intermediate product known as peat which is mainly cellulose $(C_6H_{10}O_5)_n$. Due to progressive decomposition by heat and pressure, the cellulose lost moisture H_2 and O_2 and got converted into coal as per the given equation.

Plants ⟶ Peat ⟶ Lignite ⟶ Bituminous coal ⟶ Anthracite coal

Petroleum and natural gases:

Petroleum is a complex mixture of hydrocarbons, mostly alkanes and cycloalkanes. It occurs below the earth crust entrapped under rocky strata. In its crude form, the viscous black liquid is known as petroleum and a gas in contact with petroleum layer which flows naturally from oil wells is termed as natural gases. The composition of natural gas is a mixture of mainly methane, (95.0%), small amounts of ethane, propane and butane (3.6%) and traces of CO_2 (0.48%) and N_2 (1.92%). On the world basis, petroleum deposits are found at Saudi Arab, Iraq, Iran, Kuwait, USA, Mexico, Russia etc. As per the current survey, it is found that world petroleum deposits are diminishing at a very faster rate. If preventive steps are not taken, the existing petroleum will be available maximum up to 40 years.

Fuel woods:

The rural peoples require fuel wood or fire Wood for their day to day cooking which are obtained from natural forests and plantations. Due to rapid deforestation, the availability of fire wood or fuel wood becomes difficult. This problem can be avoided by massive afforestation (plantation) on degraded forest land, cultivable waste land, barren land, grazing land etc.

Hydropower:

Energy obtainable from water flow or water falling from a higher potential to lower potential, is known as hydro- power. It is a conventional and renewable form of energy which can be transmitted to long distance through cables and wires.

Nuclear energy:

A small amount of radioactive substance (U_{235}) can produce a lot of energy through the process of nuclear fission. For example, one ton of uranium can provide energy which is much higher than three million tons of coal or 12 million barrels of oil. In order to obtain nuclear energy, nuclear reactors are required. There are around 300 nuclear reactors all over the world.

The non-conventional sources of energy used for generating power in lesser magnitude are as follows:
(a) Solar energy (b) Wind power (c) Tidal power (d) Bio-gas (e) Magneto-hydro-dynamic plant (f) Geo-thermal energy

Wind Power: Airflows can be used to run wind turbines. Wind energy is used in wind mills which converts the kinetic energy of the wind into mechanical or electrical energy. The kinetic energy of wind can be used to do mechanical work like lifting water from wells or grinding grains in flour mills. A single wind mill produces only a small amount of electricity, large number of wind mills in a large area are coupled together to produce more electricity in wind energy farms. The minimum wind speed required is 15km/hr.

Advantages:

- It is a renewable source of energy.
- It does not cause pollution.
- The recurring cost is less.
- Once the wind turbine is built the energy it produces does not cause greenhouse gases

Disadvantages:

- Wind is not available at all times.
- It requires a large area of land.
- A minimum wind speed of 15 km/h is required.

Solar Energy: Energy obtained from the sun in the form of heat and light. Energy derived in the form of solar radiation. The solar energy received by the near earth space is approximately 1.4 kilojoules/second known as solar constant. The heat energy is used in solar heating devices like solar cooker, solar water heater, solar furnaces etc. The light energy is used in solar cells.

Advantages:

- After initial investment, all the electricity you produce is free.
- It is abundant.
- It is everlasting.

- It is available almost everywhere.
- It is free from political barriers.
- Incentives and rebates from governments and utility companies offset the initial investment.
- Reduce or completely eliminate your electric bill.
- Costs of solar panels are decreasing while efficiency is increasing.

Tidal Power: Ocean waves and tides contain large amount of energy. Such tides rise and fall and water can be stored during rise period and it can be discharged during fall. Due to low head of water available low head hydroelectric plants can work successfully. These plants can utilize a head of just a few meters. During high tide the height of tide is above that of tidal basin and the turbine unit operates and generates power. During low tide the height of tide is lower than that of the tidal basin. At this time water is allowed to flow out to drive the turbine unit. At this time water is allowed to flow out to drive the turbine unit. The turbine unit does not operate if the tide sea level and basin level are equal.

Geothermal Energy: According to various theories the earth has a molten core. The fact that volcanic action takes place in many places on the surface of earth supports these theories. The steam vents and hot springs come out of earth's surface. The steam from such natural steam wells is used for the generation of power. In this type of set-up a steam drum is used. Steam drum separates moisture and solids from steam. Such system is under development in USA and USSR.

Bio-mass based energy:

The organic matters originated from living organisms (plants and animals) like wood, cattle dung, sewage, agricultural wastes etc. are called as biomass. These substances can be burnt to produce heat energy which can be used in the generation of electricity. Thus, the energy produced from the biomass is known as biomass energy.

There are three forms of biomass:

(i) Biomass in traditional form:
Energy is released by direct burning of biomass (e.g. wood, agricultural residue etc.)
(ii) Biomass in nontraditional form:
The biomass may be converted in to some other form of fuel which can release energy. For example carbohydrate can be converted into methanol or ethanol which may be used as a liquid fuel.
(iii) Biomass for domestic use:
When organic matters like cow dung, agricultural wastes, human excreta etc. subjected to bacterial decomposition in presence of water in absence of air, a mixture of CH_4, CO_2, H_2, H_2S etc. is produced. These gases together are known as biogas. The residue left after the removal of biogas is a good source of manure and biogas is used as a good source of non-polluting fuel.

3. Gas Turbine কি ধরনের engine?

Answer: A gas turbine is a rotary engine. In a gas turbine plant, the air is compressed in a rotary compressor and passed into a combustion chamber where the fuel is burnt, the product of combustion then strikes the blades of the turbine with high velocity and the work is produced.

4. Classify of gas turbine.

Answer: Gas turbines are divided into two types .They are
1. Open cycle gas turbine
2. Closed cycle gas turbine and
3. Semi-closed cycle gas turbine.

1. **Open cycle gas turbine**: If the entire working fluid in the plant is taken from the atmosphere and is again returned to the atmosphere after work is produced on the turbine.

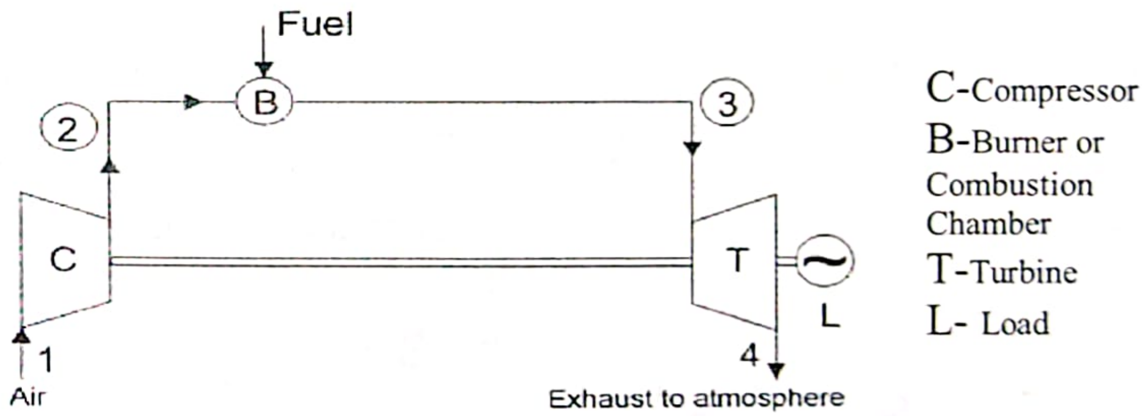
2. **Closed cycle gas turbine**: If the working fluid in the plant does not come in contact with the atmospheric air and the fluid is used over and over again.

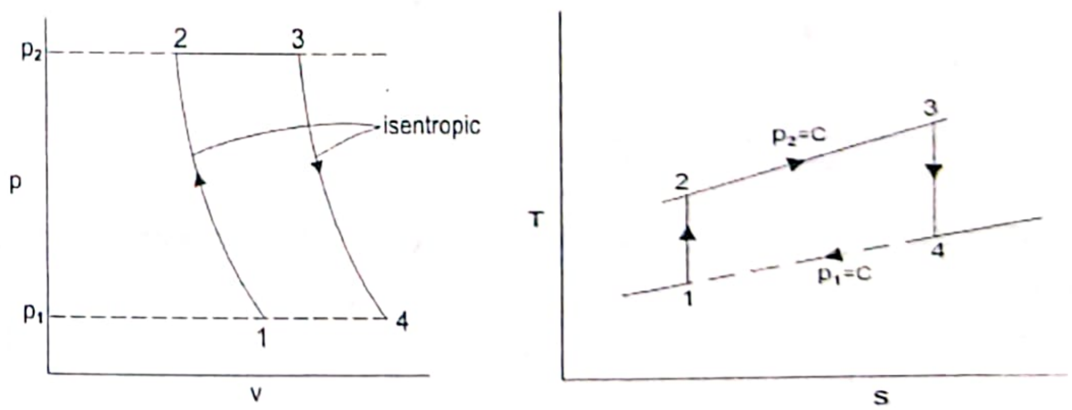
3. **Semi-closed cycle gas turbine**: If a part of working fluid is retained in a plant while the remaining part flows from and to the atmosphere.

5. Gas turbine কোন Cycle চলে?

Answer: Gas turbine Joule or Brayton Cycle চলে। The ideal cycle for the simple gas turbine is the Joule or Brayton cycle which is represented by the cycle 1234 in the p-v and T-S diagram. The cycle comprises of the following process.

1-2 is the isentropic compression occurring in the compressor, 2-3 is the constant pressure heat addition in the combustion chamber, 3-4 is the isentropic expansion in the turbine releasing power output, 4-1 is the rejection of heat at constant pressure - which closes the cycle. Strictly speaking, the process 4-1 does not occur within the plant. The gases at the exit of the turbine are lost into the atmosphere; therefore it is an open cycle.





5. Gas Turbine এর efficiency equation টা লেখ?

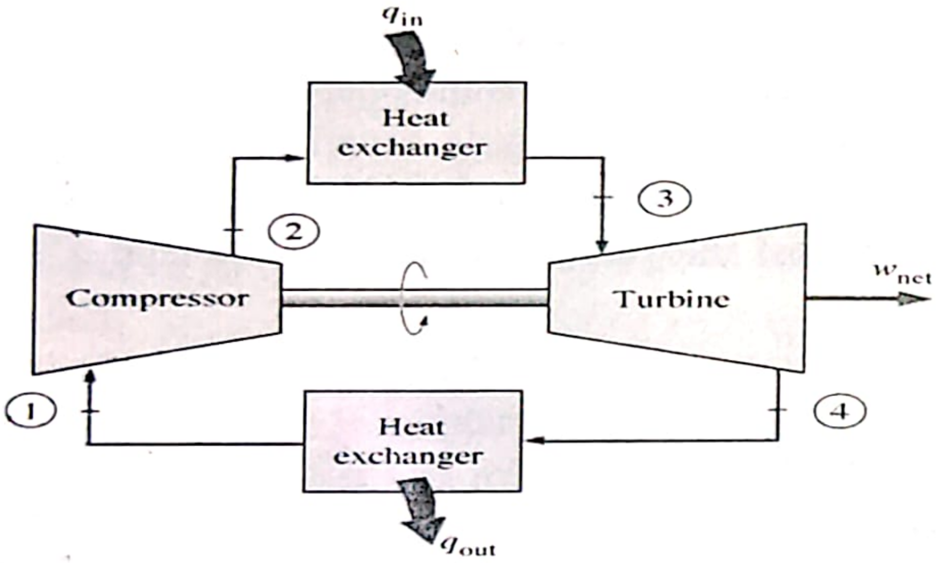
Answer: The cycle efficiency is then given by,

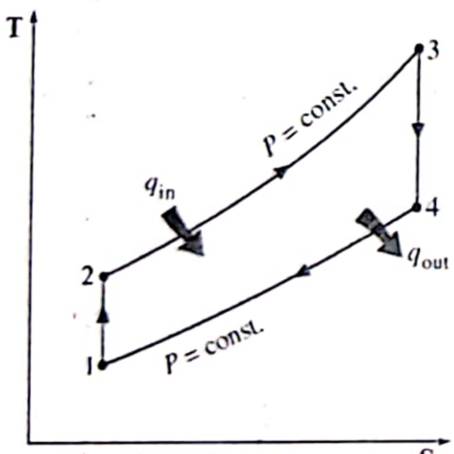
$$\eta = 1 - \frac{1}{r^{\frac{\gamma-1}{\gamma}}}$$

Where, r is pressure ratio

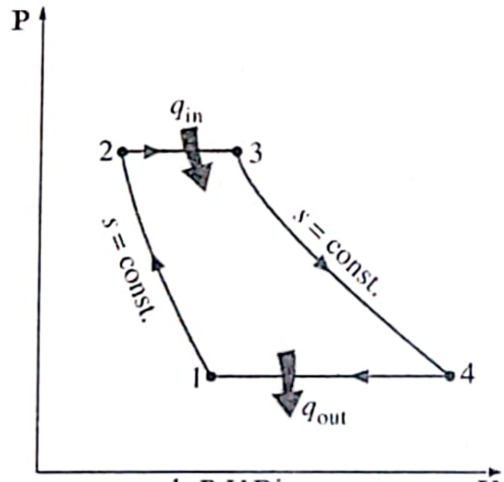
$$\frac{T_2}{T_1} = \frac{T_3}{T_4} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = r^{\frac{\gamma-1}{\gamma}}$$

6. Draw a schematic diagram with P-V and T-S and mention its different equipment for a Brayton Cycle.





a. T-S Diagram



b. P-V Diagram

7. How can be the thermal efficiency of the Brayton cycle improved.

Answer: Thermal efficiency of a Brayton cycle can be improved by- Increasing pressure ratio, Heat regeneration, Reheating and Compression with intercooling.

8. What is the defference between Regeneration and Recuperation of Heat?

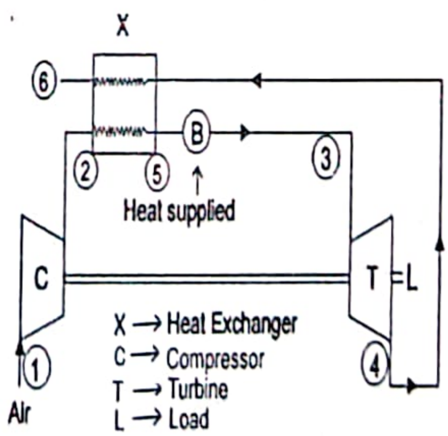
Answer: In general, the heat exchangers used in regeneration may be classified as either regenerators or recuperators.

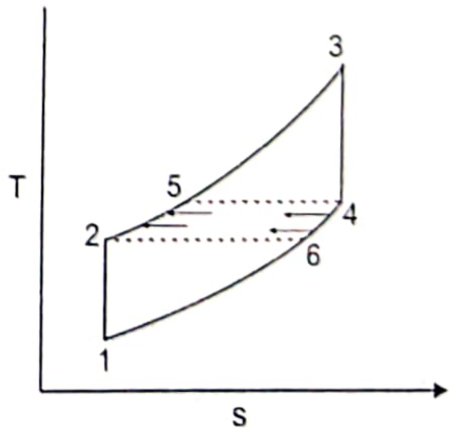
Regenerator is a type of heat exchanger where heat from the hot fluid is intermittently stored in a thermal storage medium before it is transferred to the cold fluid. It has a single flow path in which the hot and cold fluids alternately pass through.

Recuperator is a type of heat exchanger that has separate flow paths for each fluid along their own passages and heat is transferred through the separating walls. Recuperators (e.g. economisers) are often used in power engineering, to increase the overall efficiency of thermodynamic cycles. For example, in a gas turbine engine. The recuperator transfers some of the waste heat in the exhaust to the compressed air, thus preheating it before entering the combustion chamber. Many recuperators are designed as counterflow heat exchangers.

9. Draw a schematic diagram of a simple cycle with exhaust heat exchange cycle (Regenerative cycle).

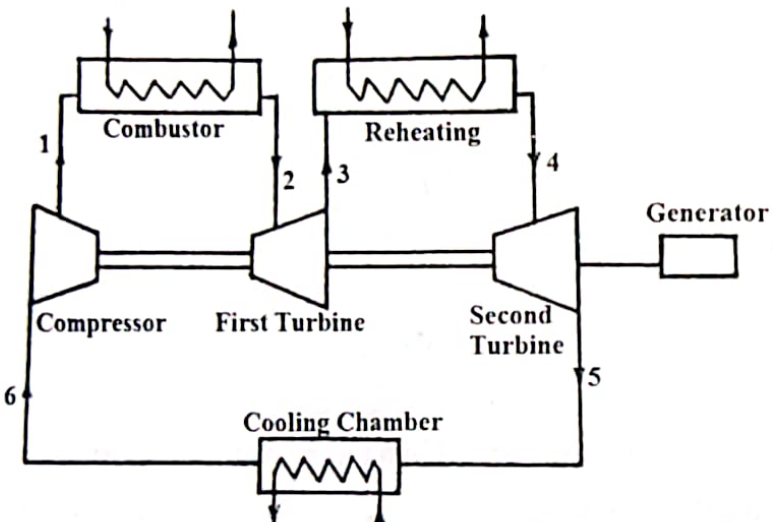
Answer: In most cases, the turbine exhaust temperature is higher than the outlet temperature from the compressor. Thus, the exhaust heat can be utilized by providing a heat exchanger that reduces heat input in the combustion chamber. This saving of energy increases the efficiency of the regeneration cycle keeping the specific output unchanged. A regenerative cycle is illustrated in Figure below:



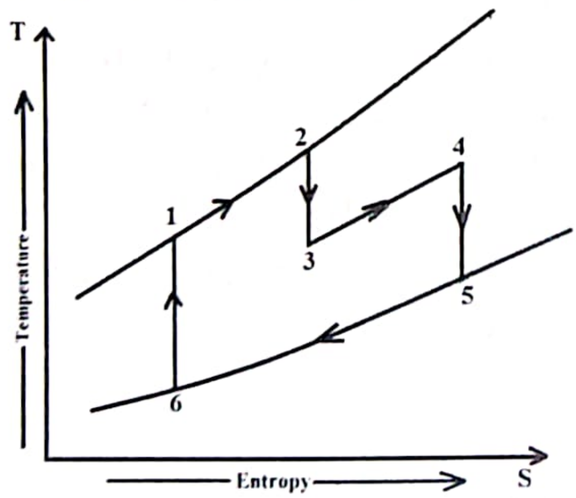


10. Draw a schematic diagram of a gas turbine cycle with reheat.

Answer: A common method of increasing the mean temperature of heat reception is to reheat the gas after it has expanded in a part of the gas turbine. By doing so the mean temperature of heat rejection is also increased, resulting in a decrease in the thermal efficiency of the plant. However, the specific output of the plant increases due to reheat. A reheat cycle gas turbine plant is shown in Figure below:



Schematic arrangement of a closed cycle gas turbine with reheating



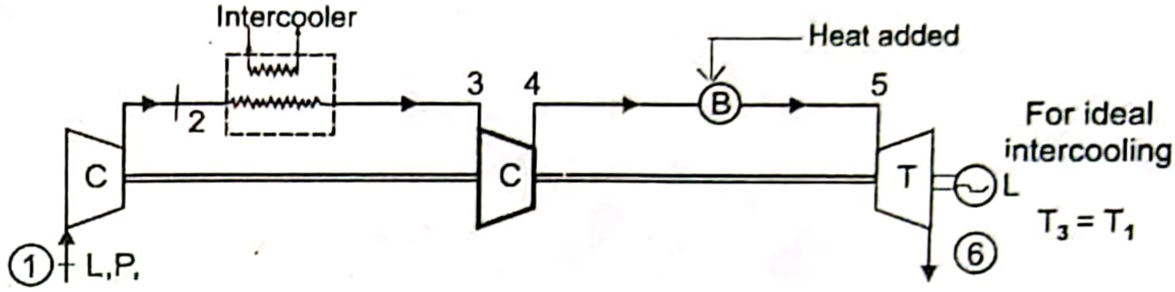
T-S Diagram for Reheating Gas Turbine Cycle

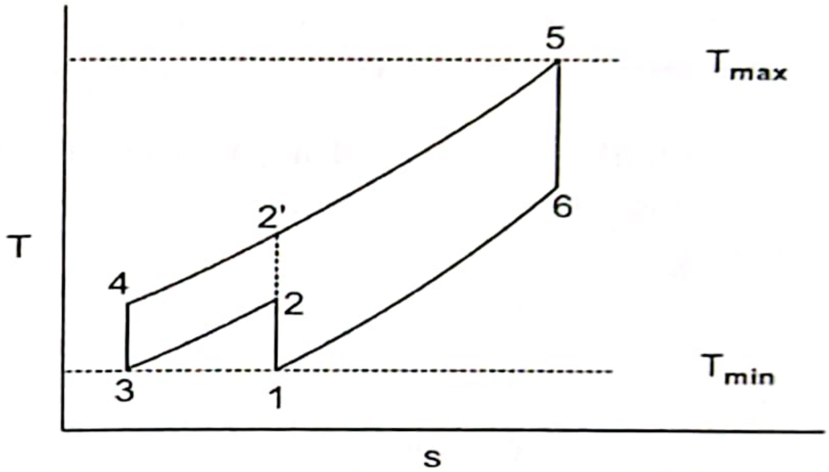
Therefore, a reheat cycle is used to increase the work output while a regenerative cycle is used to enhance the efficiency.

11. Draw a schematic diagram of a gas turbine cycle with inter-cooling.

Answer: The cooling of air between two stages of compression is known as intercooling. This reduces the work of

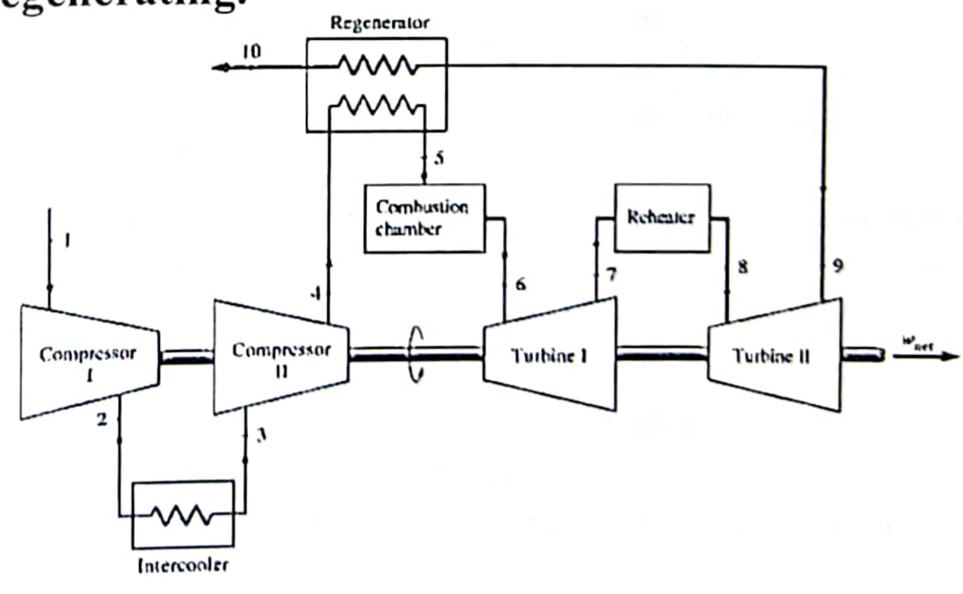
compression and increases the specific output of the plant with a decrease in the thermal efficiency. The loss in efficiency due to intercooling can be remedied by employing exhaust heat exchange in the reheat cycle.

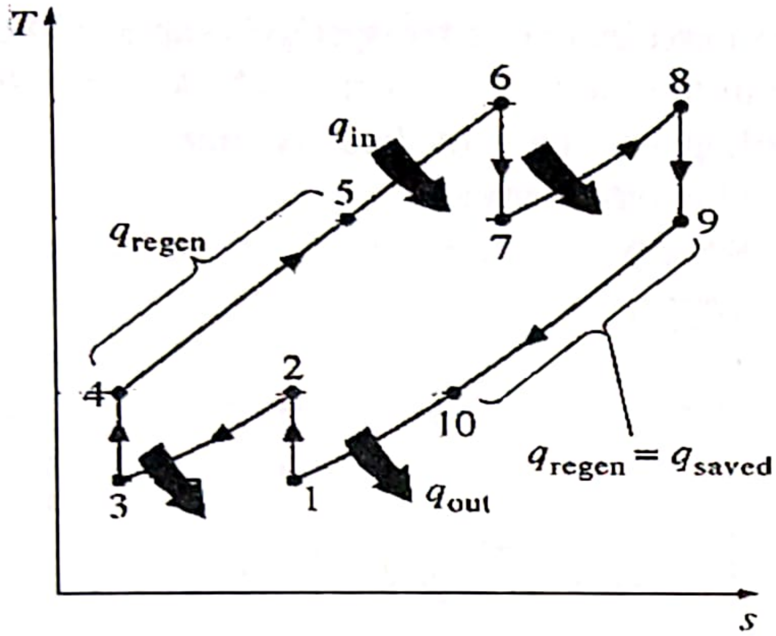




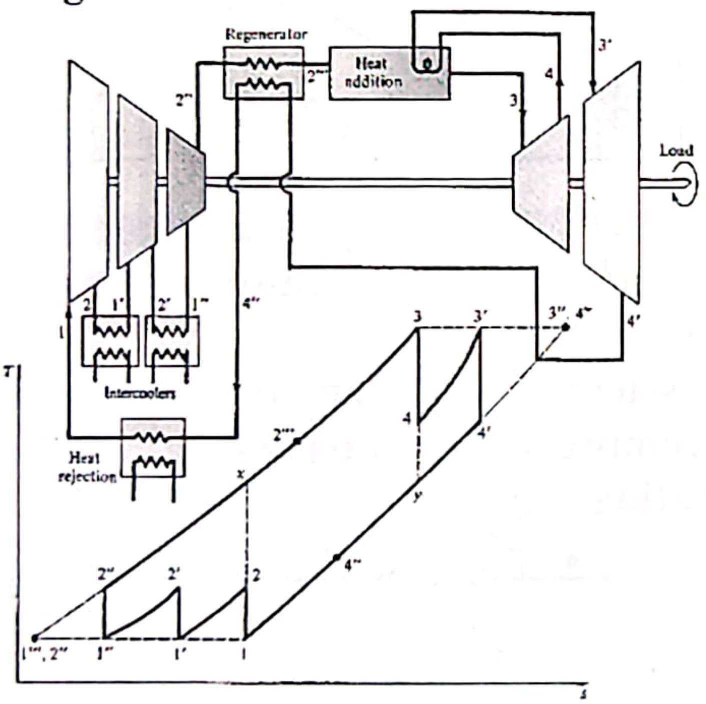
With multiple inter-cooling and multiple reheat, the compression and expansion processes tend to be isothermal as shown in Figure.

12. Draw a schematic diagram of a gas Turbine cycle with two compressors intercooling, Reheating and regenerating.





13. Draw a schematic diagram of a gas Turbine cycle with two compressor two stage intercooling, Reheating and regenerating.

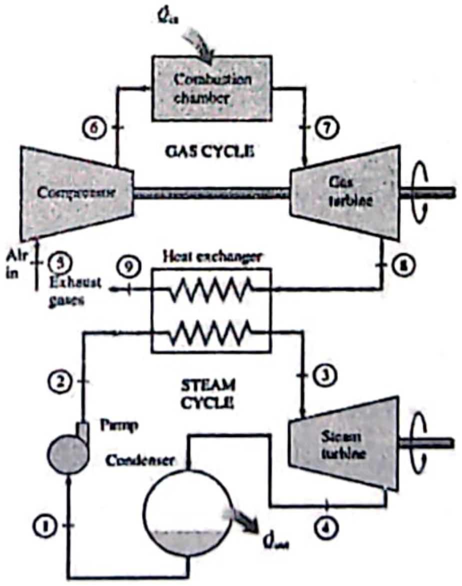


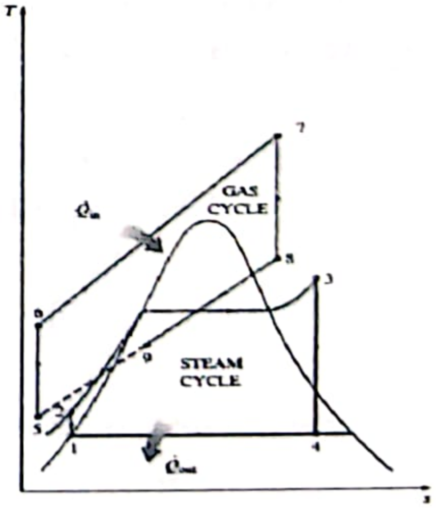
14. What is Combined Cycle power plant?

Answer: The combined cycle of greatest interest is the gas-turbine (Brayton) cycle topping a steam turbine (Rankine) cycle, which has a higher thermal efficiency than either of the cycles executed individually. Gas-turbine cycles typically operate at considerably higher temperatures than steam cycles. The maximum fluid temperature at the turbine inlet is about 620°C

(1150°F) for modern steam power plants, but over 1425°C (2600°F) for gas-turbine power plants. It is over 1500°C at the burner exit of turbojet engines. The use of higher temperatures in gas turbines is made possible by recent developments in cooling the turbine blades and coating the blades with high-temperature-resistant materials such as ceramics. Because of the higher average temperature at which heat is supplied, gas-turbine cycles have a greater potential for higher thermal efficiencies.

In this cycle, energy is recovered from the exhaust gases by transferring it to the steam in a heat exchanger that serves as the boiler. In general, more than one gas turbine is needed to supply sufficient heat to the steam. Also, the steam cycle may involve regeneration as well as reheating. Energy for the reheating process can be supplied by burning some additional fuel in the oxygen-rich exhaust gases. Recent developments in gas-turbine technology have made the combined gas–steam cycle economically very attractive. The combined cycle increases the efficiency without increasing the initial cost greatly. Consequently, many new power plants operate on combined cycles, and many more existing steam or gas-turbine plants are being converted to combined-cycle power plants. Thermal efficiencies well over 40 percent are reported as a result of conversion.





15. What is the function of air vessel, surge tank, accumulator and steam trap?

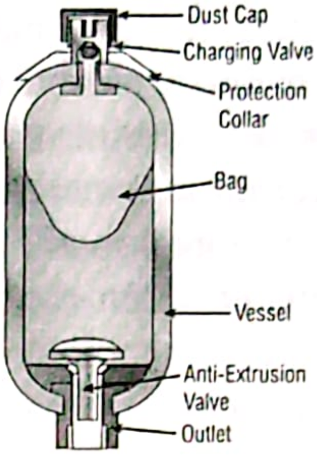
Accumulator: Accumulator is a device for storing liquid under pressure, usually consisting of a chamber separated into a gas compartment and a liquid compartment by a bladder, piston, or diaphragm. An accumulator also smoothens out pressure surges in a hydraulic system.

Application: In the fuel suction line of heavy diesel engine, suction line of control oil pump of control oil system, in refrigeration system suction line between the evaporator and the compressor.

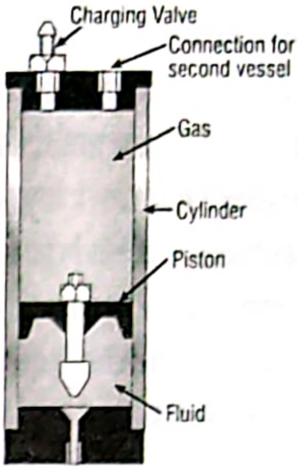
Role of Accumulator: The suction line accumulator is a temporary reservoir for this mixture, designed to meter both the liquid refrigerant and oil back to the compressor at an acceptable rate. This prevents damage to the reed valves, pistons, rods, and crankshafts. Accumulators have a metering ejector device that picks up liquid, vaporizes it, and returns it to the compressor. This prevents liquid slugging and controls oil return. It is particularly important on hot gas defrost systems, heat pumps, etc., where surges of liquid refrigerant frequently go back down the suction line.

The purpose of a hydraulic accumulator is to store hydraulic fluid under pressure. It may be used to-

- Dampen hydraulic shocks which may develop when pressure surges occur in hydraulic systems.
- Add to the output of a pump during peak load operation of the system, making it possible to use a pump of much smaller capacity than would otherwise be required.
- Absorb the increase in fluid volume caused by increase in temperature.
- Act as a source of fluid pressure for starting air craft auxiliary power units (APUs).
- Assist in emergency operations.



Bladder Accumulator



Piston Accumulator

Air Vessel: An air vessel is a closed chamber containing compressed air **in** the top portion and liquid (or water) at the bottom of the chamber. At the base of the chamber there is an opening through which the liquid (or water) may flow into the vessel or out from the vessel. When the liquid enters the air vessel, the air gets compressed further and when the liquid flows out the vessel, the air will expand in the chamber.

An air vessel is fitted to the suction pipe and to the delivery pipe at a point close to the cylinder of a single-acting reciprocating pump:

1. To obtain a continuous supply of liquid at a uniform rate.
2. To save a considerable amount of work in overcoming the frictional resistance in the suction and delivery pipes and
3. To run the pump at a high speed without separation.

It may be noted that by fitting an air vessel to the reciprocating pump, the saving of work and subsequently the power is about 84.8% in case of a single acting reciprocating pump and 39.2% in case of double acting reciprocating pump.

Surge Tanks: Surge tank is a storage reservoir fitted to the penstock at a point near to the turbine. The functions of the storage tank can be summarized as follows: When the load on the turbine decreases, the gates of the turbine are closed partly by the governor to adjust the rate of flow of water in order to maintain the constant speed of the runner. When the gates are

closed the water is moving to the turbine has to move backward. This backward moving water is stored in the surge tank. Similarly, when the load on the turbine increases, the turbine gates are opened by the governor and increased demand of water is partly met by the water stored in the surge tank. Thus the surge tank controls the water when the load on the turbine decreases and supplies water when the load on the turbine increases. In this way surge tank controls the pressure variations resulting from the rapid changes in water flow in penstock and thereby prevents water hammer effect. The functions of a surge tank are similar to a flywheel fitted to an I.C. engine.

Steam trap: Steam trap is a device which is used for separating suspended water particles carried by the steam on its way from the boiler to the engine.

16. Steam Turbine কোন সাইকেলে চলে?

Answer: Steam Turbine Rankine cycle সাইকেলে চলে।

Consider the idealized four-steady-state-process cycle in which state 1 is saturated liquid and state 3 is either saturated vapor or superheated vapor. This system is termed the Rankine cycle and is the model for the simple steam power plant. It is convenient to show the states and processes on a T–S diagram.

17. Rankine cycle এর Principle component গুলো কি?

Answer: The four basic components of Rankine cycle are shown in figure 1 each component in the cycle is regarded as control volume, operating at steady state.

Pump: The liquid condensate leaving the condenser at the state 1 is pumped to the operating pressure of the boiler. The pump operation is considered isentropic.

Boiler: The heat is supplied in the working fluid (feed water) in the boiler and thus vapour is generated. The vapour leaving the boiler is either at saturated at the state 3 or superheated at the state 3, depending upon the amount of heat supplied in the boiler.

Turbine: The vapour leaving the boiler enters the turbine, where it expands isentropically to the condenser pressure at the state 4. The work produced by the turbine is rotary (shaft) work and is used to drive an electric generator or machine.

Condenser: The condenser is attached at the exit of the turbine. The vapour leaving the turbine is wet vapour and it is condensed completely in the condenser to the state 1, by giving its latest heat to some other cooling fluid like water.

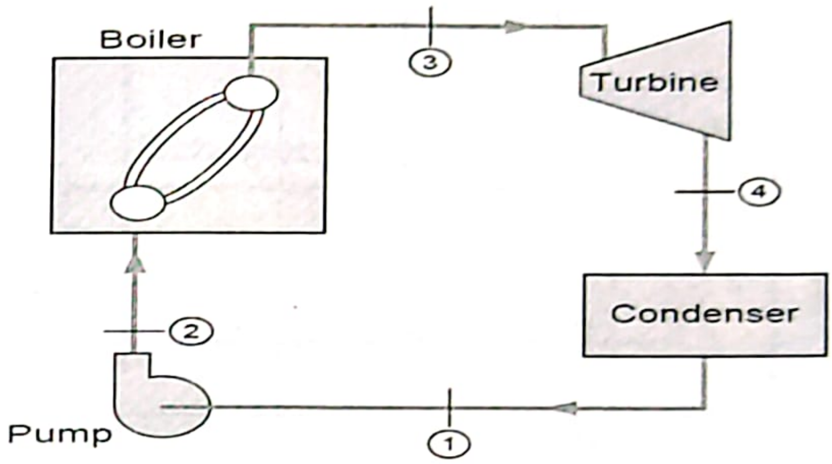


Figure 1: Simple steam power plant that operates on the Rankine cycle

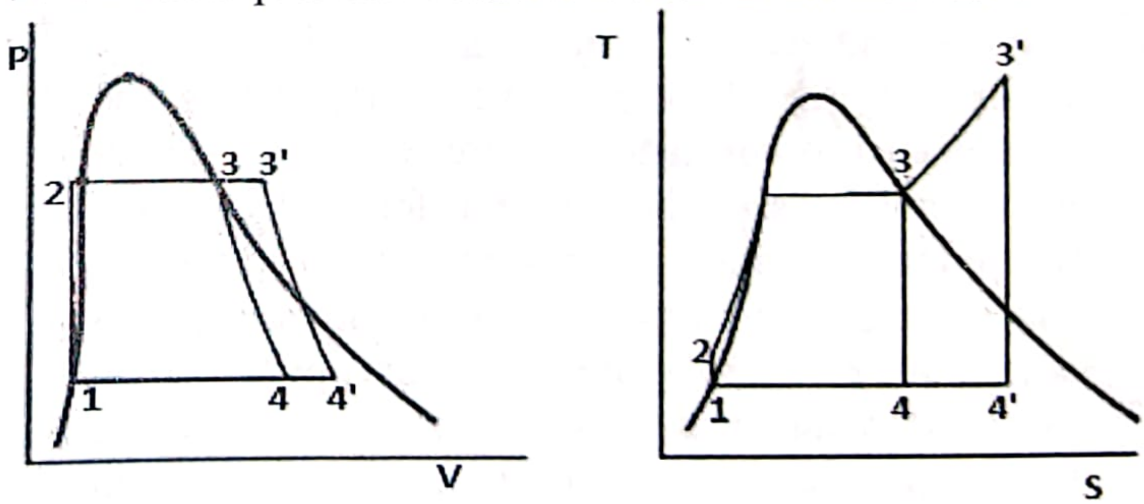
The various processes in simple Rankine cycle are:

1–2: Reversible adiabatic pumping process in the pump,

2–3: Constant-pressure transfer of heat in the boiler,

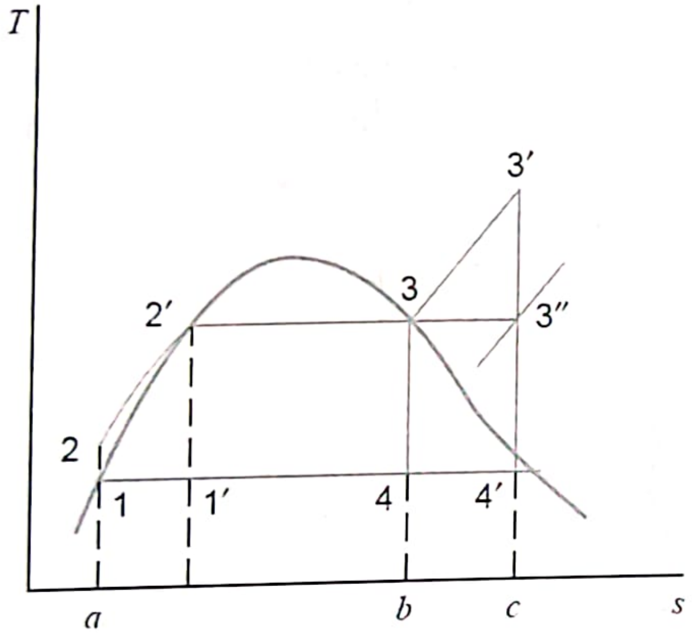
3–4: Reversible adiabatic expansion in the turbine (or other prime mover such as a steam engine),

4–1: Constant-pressure transfer of heat in the condenser.



18. Carnot cycle এর efficiency চেয়ে কম efficiency হওয়া সত্ত্বেও কেন Rankine cycle ব্যবহার করা হয়?

Answer: The Rankine cycle is chosen as ideal cycle even though thermal efficiency is less than Carnot cycle (1-2-3-4-1). This is due to mainly two reasons:



1. The first reason concerns the pumping process. State 1 is a mixture of liquid and vapor. Great difficulties are encountered in building a pump that will handle the mixture of liquid and vapor at 1 and deliver saturated liquid at 2. It is much easier to condense the vapor completely and handle only liquid in the pump: The Rankine cycle is based on this fact.
2. The second reason concerns superheating the vapor. In the Rankine cycle the vapor is superheated at constant pressure, process 3–3ꞌ. In the Carnot cycle all the heat transfer is at constant temperature, and therefore the vapor is superheated in process 3–3ꞌ. Note, however, that during this process the pressure is dropping, which means that the heat must be transferred to the vapor as it undergoes an expansion process in

which work is done. This heat transfer is also very difficult to achieve in practice.

Thus, the Rankine cycle is the ideal cycle that can be approximated in practice.

19. Draw a schematic diagram of a reheat Rankine cycle with T-S diagram.

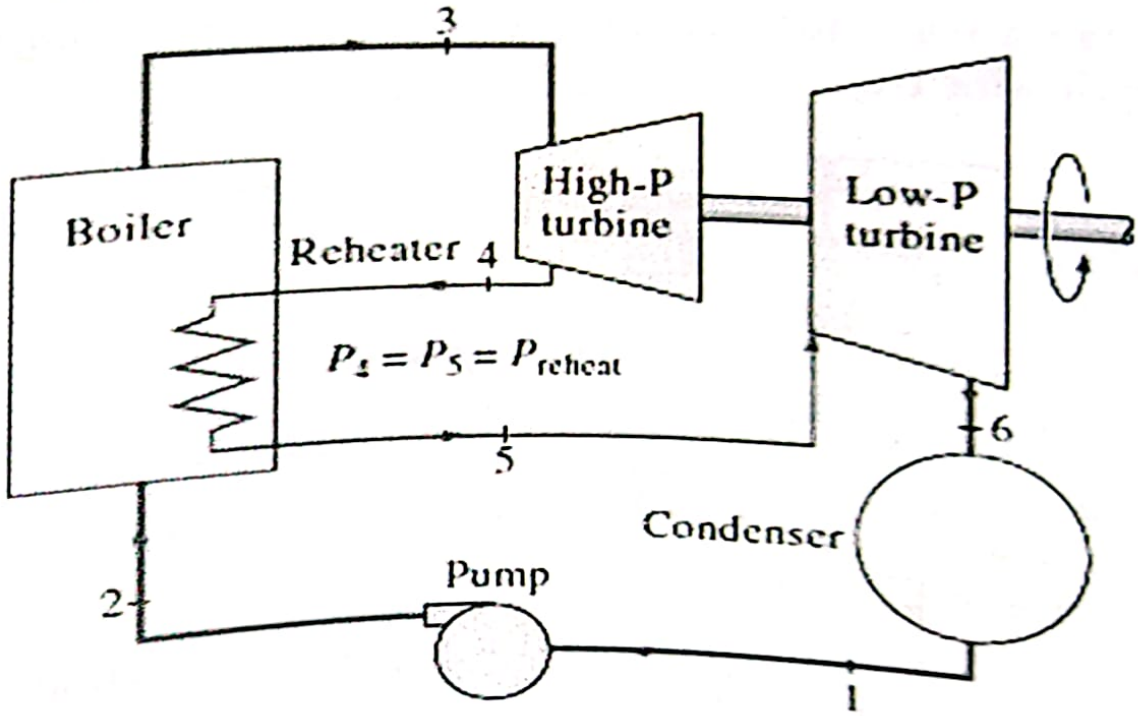


Fig.: Schematic diagram of Re-heat Cycle

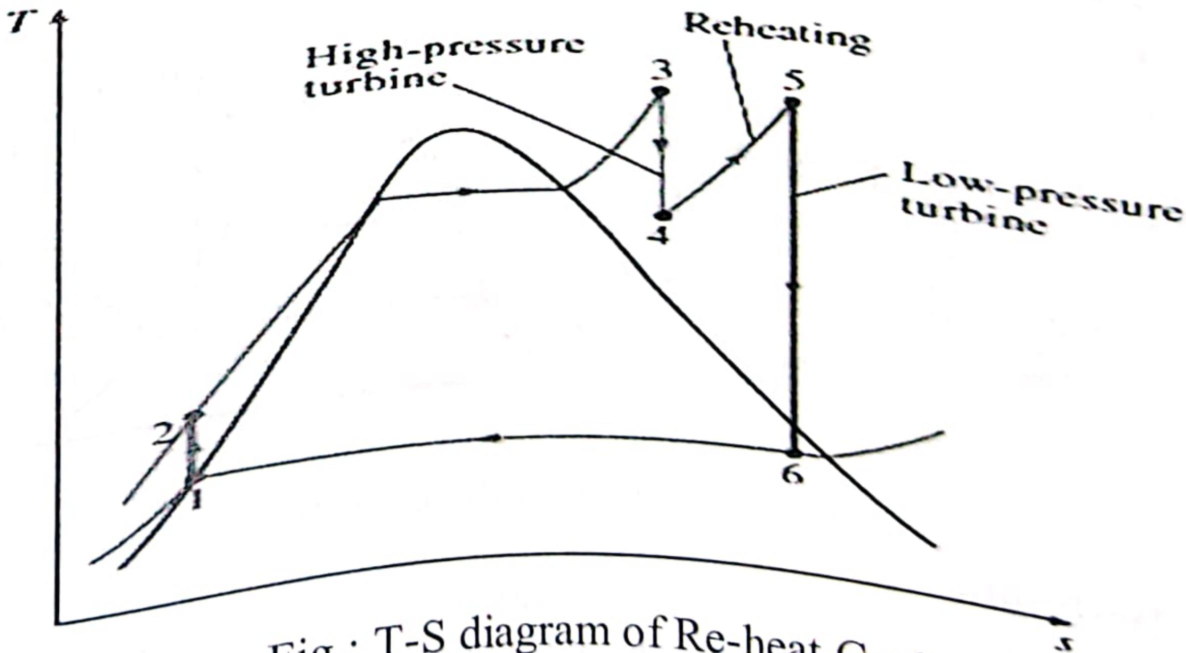


Fig.: T-S diagram of Re-heat Cycle

20. How to increase the efficiency of a Rankine cycle.

Answer: Thermal efficiency of the ideal Rankine cycle can be increased by:

(a) Lowering Condenser pressure
(b) Superheating the steam to high temperatures
(c) Increasing the boiler pressure sufficiently.

21. Draw a schematic diagram of a Co-generative Rankine cycle with T-S diagram.

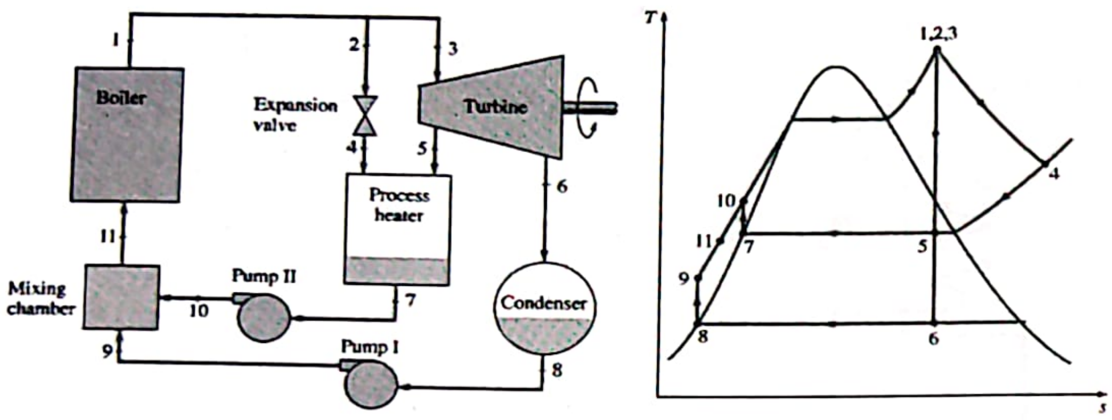


Fig.: Schematic of Co-generation

22. Draw a schematic diagram of a regenerative Rankine cycle with T-S diagram.

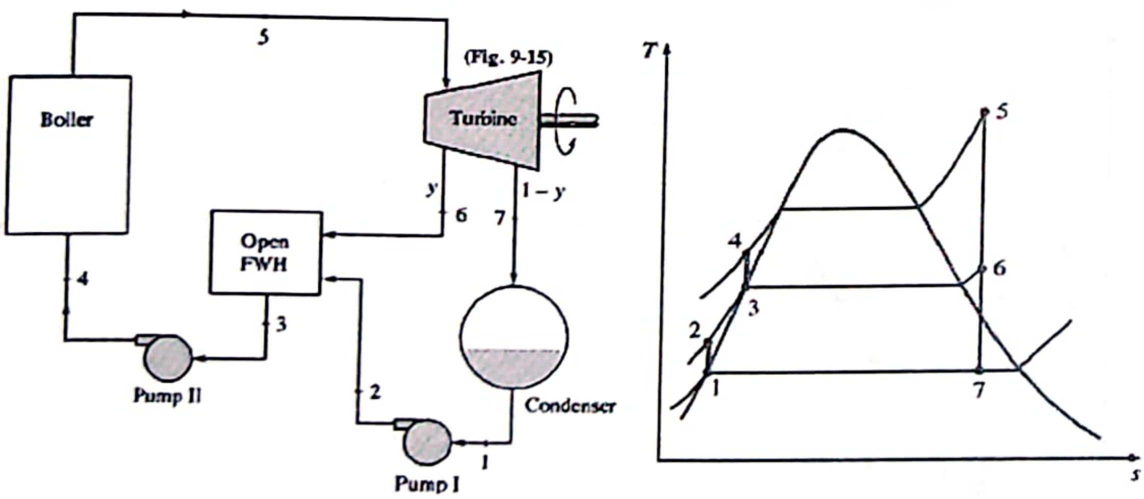


Fig.: Rankine Cycle with Regeneration

23. Draft tube কি?

Answer: The draft tube is an integral part of reaction turbine, and its design criteria should be specified by the turbine manufacturer. The draft tube used in hydraulic reaction turbine

has gradual increase in cross sectional area from its inlet to outlet. It is one of the important components of reaction turbine and connects runner exit to tail race.

The main functions of draft tube is:

- To allow the installation of turbine above the tail race level without loss of head and
- To convert major part of kinetic energy coming out of runner into pressure energy.

24. The draft tube কয় ধরনের?

Answer: (1)Conical or divergent draft tube

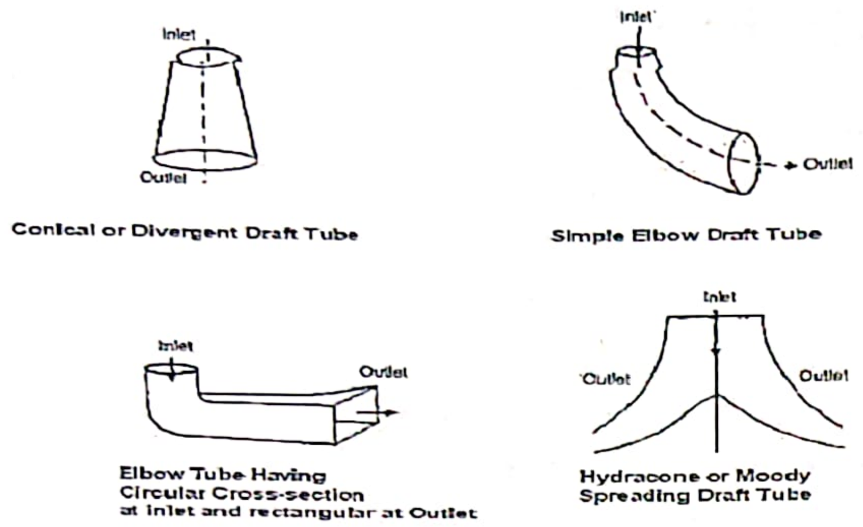
(2)Elbow type draft tube

(3)Hydracone or Moody spreading draft tube

(1)Conical or divergent draft tube: The shape of the tube resembles that of a frustrum of a cone. It is commonly used in the Francis turbine. The cone angle varies from 4° to 8°. The efficiency of the conical tube is about 8.5% to 90%.

(2)Elbow type draft tube: It may be in the form of a simple elbow type or elbow tube with a circuit inlet and a rectangular outlet section. The latter type is used in the Kaplan turbine with an efficiency of about 70%.

(3)Hydracone or Moody spreading draft tube: This is a modification of conical tube and a solid conical cone is provided in the centre of the tube with a flare at the bottom end. Such an arrangement allows a large exit area without excessive length. The solid core at the centre enables full flow and reduces the eddy losses. The efficiency of the tube is about 85%.



Types of Draft Tubes

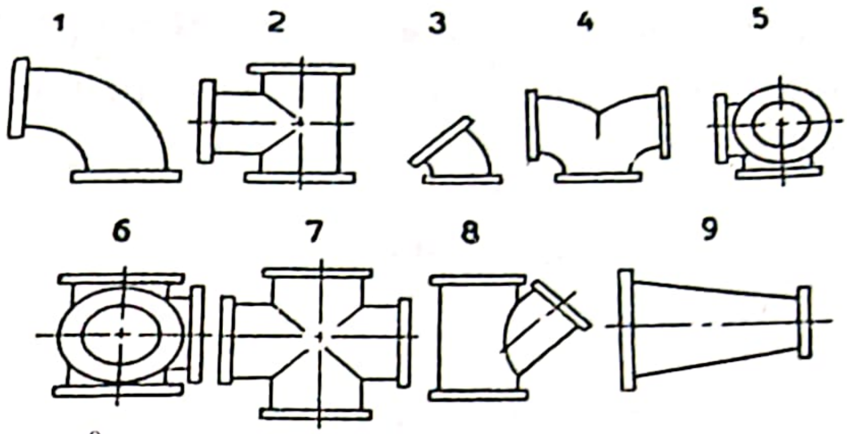
25. Pipe fittings কি?

Answer: Fittings for piping systems can be expensive and require a proportionally large labour element to install, therefore correct selection and use is important for a well-installed piping system. Every type of piping material has a range of fittings that can be used with it and some piping materials can have multiple different ranges of fittings that can be used. For example copper piping systems can be installed by bending the pipe and therefore using no elbows, using soldered copper fittings or compression brass fittings depending on the type of service being transferred in the copper pipe. Fittings are available with ends to match the piping installation therefore the following information will not differentiate between welded, threaded or compression but will concentrate on the orientation and the use of the fitting.

26. কয়েক ধরনের Pipe fittings এর নাম বলো?

Answer: The most common type of pipe fittings are:

- Elbow
- Tee
- Cross
- Reducer
- Cap
- Union



1. Elbow (90^0)
2. Tee
3. Elbow (45^0)
4. Double Branch Elbow
5. Side Outlet Elbow
6. Side Outlet Tee
7. Cross
8. Lateral
9. Reducer

Elbow: A pipe fitting installed between two lengths of pipe or tube allowing a change of direction, usually 90° or 45°. The ends may be machined for butt welding, threaded (usually female), or socketed etc.

Tee: A tee is used to either combine or split a fluid flow. Most common are equal tees which have the same body and branch diameter but there is also a wide range of reducing tees where either the branch or the body is a different diameter relative to each other.

Cross: A cross has one inlet and three outlets, or vice versa and like tees come in equal and reducing forms. A cross is more expensive than two tees but has the advantage of reduced space and requires less labour to install.

Reducers: Reducers are used to join 2 different pipe sizes together. They can be either concentric or eccentric which refers to the relative position of the center lines of the outlet and inlet.

Cap or Plug: A type of pipe fitting which is liquid or gas tight, and is used to cover the end of a pipe. A cap has a similar function to a plug. For screwed systems the cap would have female threads where a plug would have male threads.

Union: A union is similar to a coupling, except it is designed to allow quick and convenient disconnection of pipes for maintenance or fixture replacement.

27. Power plant কয় ধরনের?

Answer: Types of power plant:

**On the basis of fuel used-

a) Diesel
b) Steam – (i) Condensing and (ii) Non-condensing
c) Hydro
d) Gas turbine and (e) Nuclear

** On the basis of nature of load-

a) Base load and (b) Peak load

** On the basis of location-

a) Central and (b) Isolated

** On the basis of service provided-

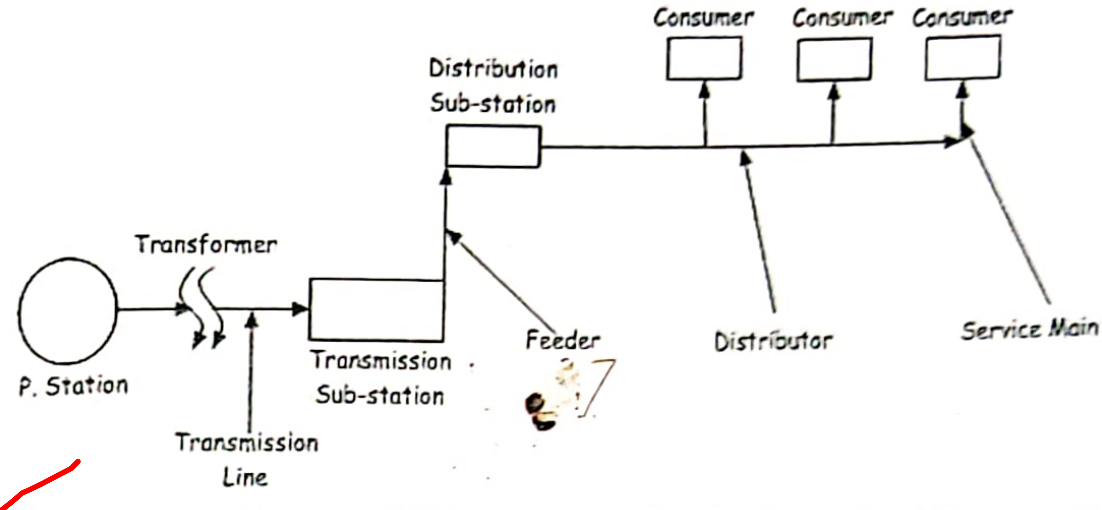
a) Stationary and (b) Locomotive (mobile)

28. কিসের উপর ভিত্তি করে power plant design করা হয়?

Answer: Requirement of power plant design/ Design Criteria:

(i) Economy of expenditure i.e. minimum (a) capital cost and
(b) maintenance/operation cost
(ii) Safety of plant and personnel
(iii) Reliability and Efficiency
(iv) Ease of maintenance
(v) Good working condition
(vi) Minimum Transmission cost

29. Draw a Power transmission Layout.



30. Draw a Power Triangle and define Active power, reactive power, Power factor and apparent power.

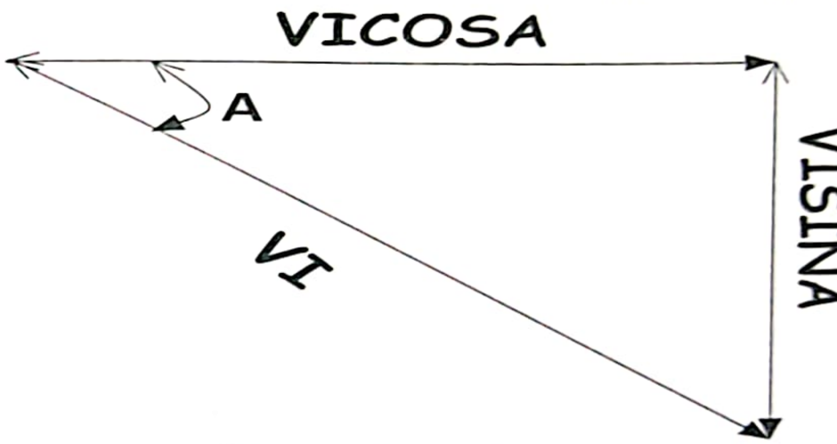


Figure: Power Triangle

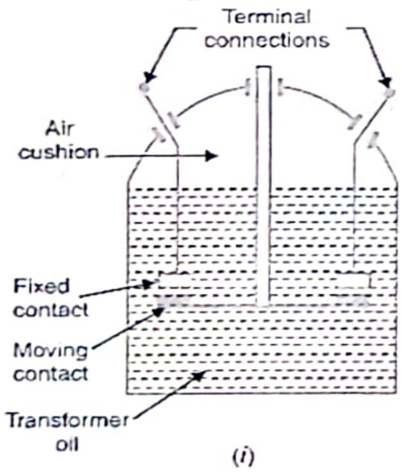
Active Power: VICosA reprepresents the active power in KW.
Reactive Power: VISinA represents the reactive power in VAR or KVAR.
Apparent Power: VI represents the apparent power in VA or KVA.
Power Factor = CosA= Active Power/ Reactive Power = The cosine angle between voltage and current in an a.c. circuit is known as power factor. = Resistace/Impedance

31. Circuit Breaker কি এবং কেন ব্যবহার করা হয়?

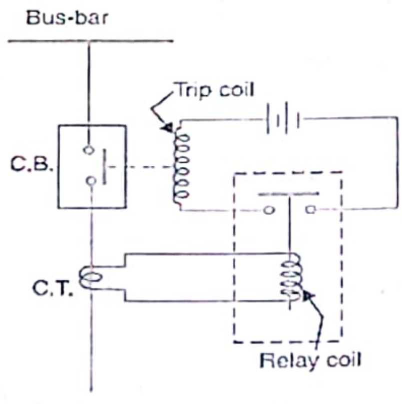
Answer: A circuit breaker is an equipment that breaks a circuit either manually or automatically under all conditions at no load, full load or short circuit.

A circuit breaker is an equipment which can open or close a circuit under all conditions viz. no load, full load and fault conditions. It is so designed that it can be operated manually (or by remote control) under normal conditions and automatically under fault conditions. For the latter operation, a relay circuit is used with a circuit breaker. Fig. (i) shows the parts of a typical oil circuit breaker whereas Fig. (ii) shows its control by a relay circuit. The circuit breaker essentially consists of moving and fixed contacts enclosed in strong metal tank and immersed in oil, known as transformer oil.

Under normal operating conditions, the contacts remain closed and the circuit breaker carries the full-load current continuously. In this condition, the e.m.f. in the secondary winding of current transformer (C.T.) is insufficient to operate the trip coil of the breaker but the contacts can be opened (and hence the circuit can be opened) by manual or remote control. When a fault occurs, the resulting overcurrent in the C.T. primary winding increases the secondary e.m.f. This energises the trip coil of the breaker and moving contacts are pulled down, thus opening the contacts and hence the circuit. The arc produced during the opening operation is quenched by the oil. It is interesting to note that relay performs the function of detecting a fault whereas the circuit breaker does the actual circuit interruption.



(i)



(ii)

Operating Principle:Two contacts called electrode remains closed under normal operating conditions. When fault occurs

on any part of the system, the trip coil of the circuit breaker get energized and contacts are separated.

32. বিভিন্ন ধরনের **Circuit Breaker** এর নাম এবং তাদের ফাংশন বলো।

MCB (Miniature Circuit Breaker)

Rated current not more than 100 A.

Trip characteristics normally not adjustable.

Thermal or thermal-magnetic operation.

MCCB (Moulded Case Circuit Breaker)

Rated current up to 1000 A.

Trip current may be adjustable.

Thermal or thermal-magnetic operation.

ACB (Air Circuit Breaker)

Rated current up to 10,000 A.

Trip characteristics often fully adjustable including configurable trip thresholds and delays.Usually electronically controlled some models are microprocessor controlled. Often used for main power distribution in large industrial plant, where the breakers are arranged in draw-out enclosures for ease of maintenance.

VCB (Vacuum Circuit Breaker)

With rated current up to 3000 A.

These breakers interrupt the arc in a vacuum bottle. These can also be applied at up to 35,000 V. Vacuum circuit breakers tend to have longer life expectancies between overhaul than do air circuit breakers.

Sulphur Hexafluoride (SF6) circuit breaker:

1. Sulphur Hexafluoride (SF6) gas is used as an arc quenching medium.SF6 is an electro-negative gas.
2. It has strong tendency to absorb electrons.
3. When contact is opened in a high pressure flow of SF6 gas, arc produced.
4. It is much effective for high power and high voltages services. (Such as- 235KV, 400KV etc.)

CT: CT means current transformer. It is used to measure the amount of current in a line by a predefined CT ratio. CT

protects the transformer by reducing the current of the main line according to the CT ratio.

PT: PT means potential transformer. It is used to measure the amount of voltage in a line. It protects the transformer by dropping the voltage of the line according to the PT ratio. It is also used to measure the amount of power transmitted through the line.

33. What is relay and what its function?

Relays: A relay is a device which detects the fault and supplies information to the breaker for circuit interruption. Fig.(ii) shows a typical relay circuit. It can be divided into three parts viz.

(i) The primary winding of a current transformer (C.T.) which is connected in series with the circuit to be protected. The primary winding often consists of the main conductor itself.

(ii) The second circuit is the secondary winding of C.T. connected to the relay operating coil.

(iii) The third circuit is the tripping circuit which consists of a source of supply, trip coil of circuit breaker and the relay stationary contacts.

Under normal load conditions, the e.m.f. of the secondary winding of C.T. is small and the current flowing in the relay operating coil is insufficient to close the relay contacts. This keeps the trip coil of the circuit breaker unenergised. Consequently, the contacts of the circuit breaker remain closed and it carries the normal load current. When a fault occurs, a large current flows through the primary of C.T. This increases the secondary e.m.f. and hence the current through the relay operating coil. The relay contacts are closed and the trip coil of the circuit breaker is energised to open the contacts of the circuit breaker.

34. What is the function of a fuse?

Answer: A fuse is a short piece of wire or thin strip which melts when excessive current flows through it for sufficient time. It is inserted in series with the circuit to be protected.

Under normal operating conditions, the fuse element it at a temperature below its melting point. Therefore, it carries the normal load current without overheating. However, when a short circuit or overload occurs, the current through the fuse element increases beyond its rated capacity. This raises the temperature and the fuse element melts (or blows out), disconnecting the circuit protected by it. In this way, a fuse protects the machines and equipment from damage due to excessive currents. It is worthwhile to note that a fuse performs both detection and interruption functions.

35. What are the differences between fuse and circuit breaker?

Answer:

Particular	Fuse	Circuit Breaker
1. Function	It performs both direction and interruption functions.	It performs interruption functions only. The detection of fault is made by relay system.
2. Operation	Inherently complete automatic.	Requires elaborate equipment (i.e. relays) for automatic action.
3. Breaking Capacity	Small	Very Large
4. Operating Time	Very small (0.002see or so)	Comparatively large (0.1 to 0.2 sec)
5. Replacement	Requires replacement after every operation.	No replacement after operation.

36. Generator কি? এর Main part গুলোর নাম বলো?

Answer: Generator is a machine which converts the mechanical energy to electrical energy.

Main parts of a generator:

1. Magnetic frame or yoke
2. Pole-core and pole-shoes
3. Pole-coils or field coils
4. Armature core
5. Armature windings or conducts
6. Commutator
7. Brushes and bearings

Function of the main parts

1. **Magnetic frame or yoke**: (a) Mechanical support (b) Carries the flux produced by pole

2. **Pole-shoes**: (a) Spread out the flux in the air gets being of larger cross-section; reduce the reluctance of magnetic path

(b) They support the acting coils.

Pole construction:

- A solid place made of either cast iron or cast steel but the pole shoe is laminated and fastened to the pole face by means of counter work.
- In modern design, the complete pole cores and pole shoes are built of thin laminations of annealed steel which are riveted under hydraulic pressure.

3. **Pole-coils**: Consists of copper wire or strip, are formed to work for the correct dimension.
4. **Commutator**: The function of the commutator is to facilitate collection of current from the armature conducts. If rectified i.e. converts the alternating current induced in the armature conductors into unidirectional current in the external load circuit, insulated by layer of mica.

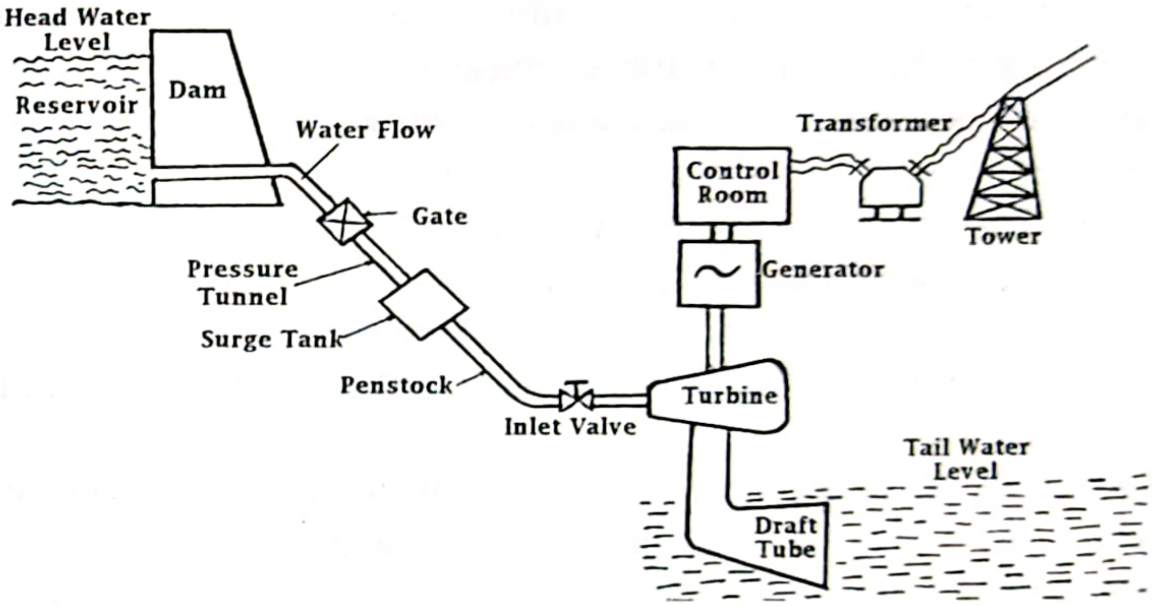
37. একটা হাইড্রো পাওয়ার প্লান্টে কি কি Component থাকে?

Answer: Components of a Hydraulic power plant.

The main components of a hydroelectric power plant are given below:

1. Power House
2. Penstock
3. Water Reservoir
4. Water Turbine or Hydraulic Turbine (Prime mover)
5. Spillway
6. Dam
7. Surge Tank
8. Draft Tube
9. Tail Race Level
10. Gate
11. Pressure Tunnel

Power House: Power house contain generator, water turbine, with transformer and control room. When the water rushes through the turbine, it turns the turbine shaft, which is attached to electric generator. Generator has a rotary electromagnet call a rotor with a stationary element call a stator. Rotors generate magnetic fields that create an electric charge in stator. Charge is transmitting as electricity. Step up transformer increase the voltage of current coming as of the stator. Electricity is dispersed through power lines.



Penstock: Penstock pipe is use to convey water as of the dam to hydraulic turbine. Penstock pipes are invented of steel or reinforced material. Turbine is installing at a lesser level as of the dam. Penstock is given by a gate valve at inlet to totally close the water supply. It has a control valve to control water flow rate into turbine.

Water Reservoir: In reservoir water collect as of the catchment area during raining period is store at the back a dam. Catchment area obtains its water as of rains with streams. Permanent accessibility of water is an essential necessity for a hydroelectric power plant. The stage of water surface in reservoir is call Head water level. Eater head presented for power generation depends on reservoir height.

Water Turbine or Hydraulic Turbine (Prime mover): Hydraulic turbines change energy of water in mechanical energy. Mechanical energy (revolution) accessible on turbine shaft is attached to shaft of an electric generator with electricity is created. Water after performing work on turbine blade is discharge through draft tube. Prime movers which are in regular use are Francis turbine, Pelton wheel, Kaplan turbine.

Spillway: Overload addition of water endangers the strength of dam construction. Also in order to shun the overflow of water out of dam mainly during raining seasons spillways are providing. This prevents the increase of water level in dam. Spillways are passage which allows excess water to flow to a dissimilar storage area away as of the dam.

Dam: The function of dam is to store water with to control the outgoing flow of water. Dam helps to store all incoming water. It too helps to raise the head of water. In order to make a necessary quantity of power, it is needed that an enough head is available.

Surge Tank: Surge tank is a little tank or reservoir in which water level rise or waterfall due to unexpected changes in pressure. There might rapid enhance of pressure in penstock pipe due to rapid backflow of water, as load on turbine is condensed. This rapid rise of pressure in penstock pipe is identified as water hammer. Surge tank is initiated among the dam with the turbine and serves the follow reason:

- To decrease the distance among the free water surface in dam and turbine, thus dropping the water hammer cause. Otherwise, penstock will damage with the water effect.
- To provide as a supply tank to turbine while the water in pipe is accelerates during amplified load situation and as a storage tank while the water is decelerating during reduced load situation.

Draft Tube: Draft tube is joined to outlet of turbine. It changes the kinetic energy available in water in pressure energy in diverge section. Therefore, it retain a pressure of just above the

over the atmospheric at end of draft tube to travel the water into a tail race. Water as of the tail race is free for irrigation reason.

Tail Race Level: Tail race is a water path to guide the water discharge as of the turbine to river or canal. Water held in the tail race is call Tail race water level.

Gate: Gate is use to adjust or control the flow of water as of the dam.

Pressure Tunnel: The way that carries water as of the reservoir to surge tank.

35. একটা nuclear power plant এ কি কি Component থাকে?

Answer: The main components of a nuclear power plant are:

1. Nuclear Reactor
2. Nuclear Fuel
3. Control Rods
4. Steam Generator
5. Reflector
6. Moderator
7. Condenser
8. Shielding
9. Turbine

Nuclear Reactor: Nuclear reactor might be regard as a substitute for boiler furnace of steam power plant. Heat formed in reactor due to nuclear fission of fuel. Through the fission method, the large quantity of heat is liberated. This large quantity of heat is immersed with the coolant and it is scattered through the core.

The different kind of reactors use in nuclear power plant is:

1. Pressurized water reactor
2. Boiling water reactor
3. Fast breeder reactor

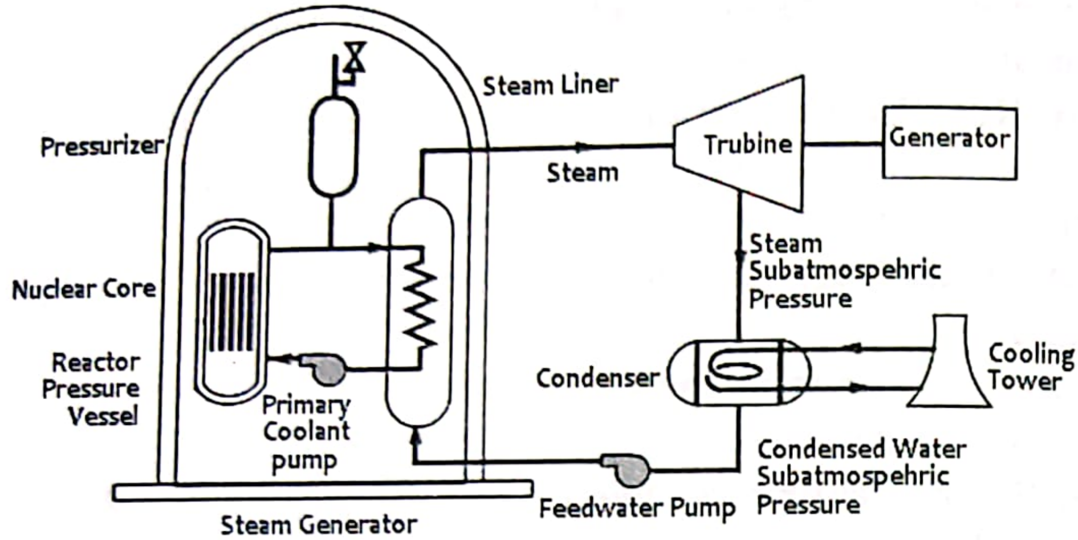


Fig.: A Typical Pressurized Water Reactor

Nuclear Fuel: Fuel of a nuclear reactor must be fissionable substance which can be define as an element or isotope whose nuclei can cause to endure nuclear fission with nuclear offensive with to generate a fission chain reaction. It can be one or every of following U_{233}, U_{235} and Pu_{239}.

Control Rods:

1. They must be enough strong and should be able to shut down the reactor about directly under all situation.
2. They must contain enough cross sectional area for the absorption.
3. They must contain sufficient heat transfer property.
4. They must be constant under heat and radiation.
5. They must be corrosion opposing.

Steam Generator: Heat liberate in reactor is in use up with the coolant circulating through core. The function of coolant is to move the heat produce in reactor core with use it for steam generation. Ordinary water or heavy water is a general coolant.

Reflector: Neutrons formed during the fission method will be partially engrossed by fuel moderator, rods, coolant or structural material and so on. Neutrons left unabsorbed will endeavor to leave reactor core and will be mislaid. Such loss is reducing by surrounding the reactor core with a material call reflector which will send neutrons back in core. Return

neutrons can then source more fission with improve the neutrons economy of reactor. Commonly the reflector is invented of beryllium and graphite.

Moderator: Moderator is use to decrease kinetic energy of fast neutrons into slows neutrons with to amplify the possibility of chain reaction. Heavy water, Graphite and beryllium are commonly use as moderator. A moderator must possess the following property:

1. It must contain high melting point lest of solid moderators with low melting point in case of liquid moderators. Solid moderators must also have fine machinability and strength.
2. It must be accessible in large amount in pure form.
3. It must be constant under heat and radiation.
4. It must have elevated thermal conductivity.
5. It must give good resistance to corrosion.
6. It must be able to slow neutrons
7. Condenser Exhaust steam as of turbine flows to condenser where cooling water is circulated. Exhaust steam is reduced to water in condenser through cooling. Condensate is pump over into the steam generator through the feed pump.
8. Shielding Reactor is a cause of strong radioactivity. These radiations are extremely dangerous and protecting is providing to soak up the radioactive rays. A thick concrete shielding with a pressure vessel is providing to stop the radiations escaped to environment.
9. Turbine Steam formed in steam generator is passed to turbine. Work is done through the expansion of stem in turbine.

36. Define Aircraft Engines and Propulsion System.

Answer: The modern aircraft engine have the ability to actuate massive airstream and thus to produce high thrust. The engine airflow rate is perhaps 50 times the fuel flow rate, and the term air breathing engine is quite appropriate. Thus, a continuous stream of air flows through the air-breathing engine. The air is compressed, mixed with fuel, ignited, expanded through a turbine and then expelled as the exhaust gas.

37. State some name and working function of aircraft engines.

Answer: The following four types of aircraft engines are generally used

- Turbojet Engine
- Turboprop Engine
- Turbofan Engine
- Ramjet Engine

At low speeds, propeller propulsion is more efficient than jet propulsion. Conventional propellers, however, become inefficient and noisy at flight speeds higher than 0.5 or 0.6 times the speed of sound. In contrast, turbojet and turbofan engines can function efficiently and quietly at flight speeds as high as 0.85 times the speed of sound. Turbojets can also operate at supersonic flight speeds. Ramjet, which is the simplest of all air-breathing engines can operate at a higher speed than turbojet engines and is mostly suitable for supersonic flight.

38. State the working principle of a Turbojet Engine.

Answer: The turbojet engine consists of a gas turbine, the output of which is used solely to provide power to the compressor. The compressor and the turbine are normally mounted on common shaft. Air is taken into the engine through an approximate diffuser duct, passes through the compressor and enters the combustion chamber, where it is mixed and burned with fuel.

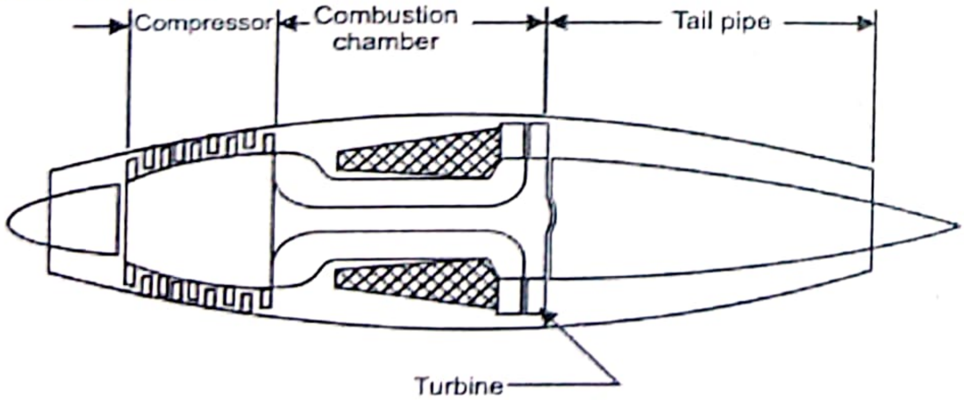


Figure: Turbojet

Most common fuels are hydrocarbons (Aviation kerosene). The ratio of fuel to air is determined by the maximum allowable gas temperature permitted by the turbine. Normally, a considerable excess air is used. The hot high pressure gases are then expanded through the turbine to a pressure which is higher than the ambient atmosphere, and yet sufficiently lower than the combustion chamber pressure, to produce just enough power in the turbine to run the compressor. After leaving the turbine, the gas is expanded to the ambient pressure through an appropriate nozzle. As this occurs, the gas is accelerated to a velocity, which is greater than the incoming velocity of the ingested air, and therefore produces a propulsive thrust.

39. State the working principle of a Turboprop Engine.

Answer: In this engine, a higher proportion of the total available pressure drop from the combustion chamber to the atmosphere is taken through the turbine and a smaller proportion through the propulsive nozzle. This strategy produces excess power in the turbine. The excess power is used not only to drive the compressor, but also to drive a propeller, in the same way as in the conventional reciprocating engines. Here the major portion of the thrust is generated by the propeller.

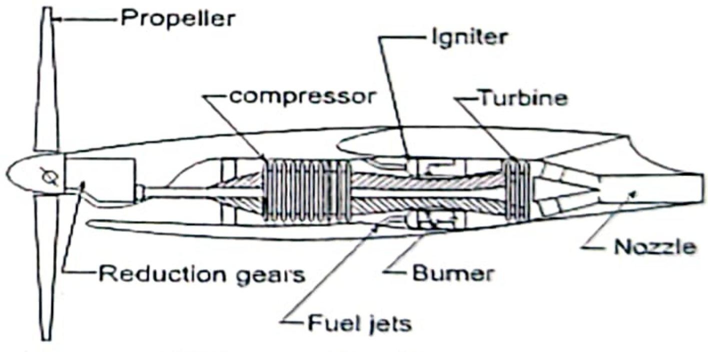


Figure: Turboprop

41. State the working principle of a Turbofan Engine.

Answer: In a turbofan engine, the air is sucked by the engine inlet. Some of the incoming air passes through the fan and continues on into the core compressor and then the burner, where it is mixed with fuel and combustion occurs. The hot

exhaust passes through the core and fan turbines and then out the nozzle, as in a basic turbojet. The rest of the incoming air passes through the fan and bypasses, or goes around the engine, just like the air through a propeller. The air that goes through the fan has a velocity that is slightly increased from free stream. So a turbofan gets some of its thrust from the core and some of its thrust from the fan. The ratio of the air that goes around the engine to the air that goes through the core is called the bypass ratio.

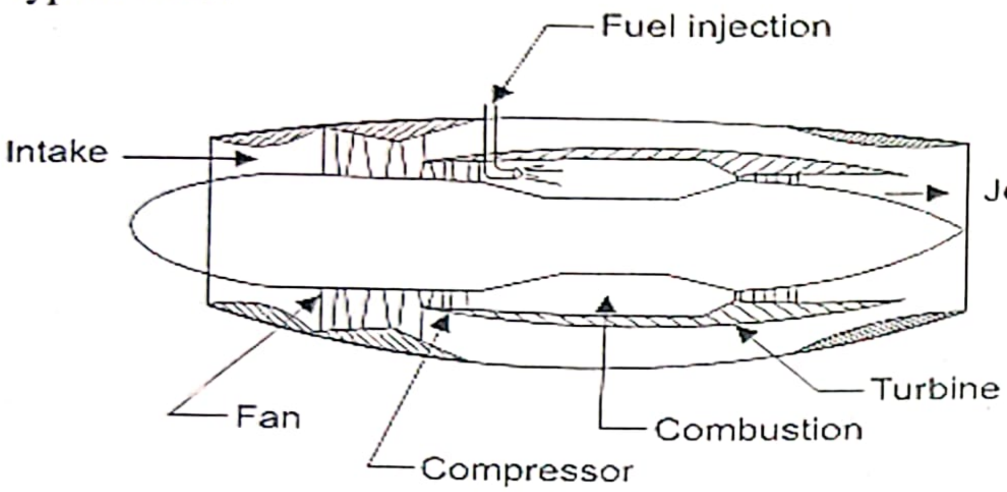


Figure: Turbofan

Because the fuel flow rate for the core is changed only a small amount by the addition of the fan, a turbofan generates more thrust for nearly the same amount of fuel used by the core. This means that a turbofan is very fuel efficient. In fact, high bypass ratio turbofans are nearly as fuel efficient as turboprops.

42. State the working principle of a Ramjet Engine.

Answer: At higher forward speeds, the ram pressure of the air is already very large, and the necessity for a compressor tends to disappear. A turbojet engine minus the compressor and turbine, but with a combustion chamber, is known as a ramjet engine. Such engines simply consists of

1. A duct designed to diffuse the incoming air, slowing its velocity and raising its pressure.
2. A combustor, designed to heat the air, normally by combustion with a liquid fuel.

3. A nozzle, designed to expand and accelerate the heated gases rearwards

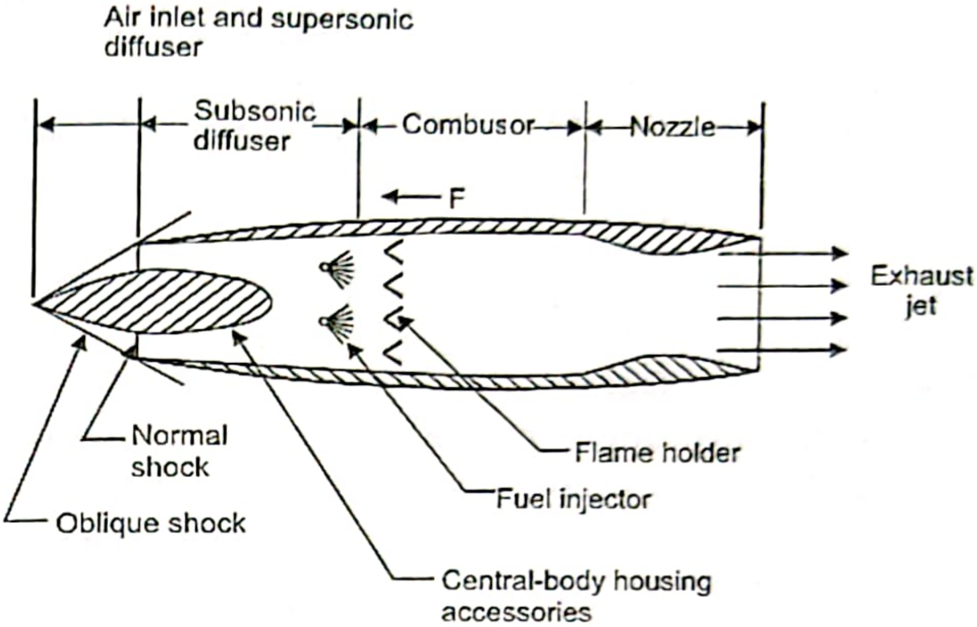


Figure: Ramjet

The ramjet engine does not accelerate itself from a standing start but requires some other form of propulsion, usually a rocket, to accelerate it to near its operating speed.

নিচের সংজ্ঞাগুলো জেনে রাখা জরুরী

(i) Connected load: It is the sum of continuous ratings of all the equipment connected to supply system.

(ii) Maximum demand: It is the greatest demand of load on the power station during a given period.

(iii) Demand factor: It is the ratio of maximum demand on the power station to its connected load i.e., Demand factor =Maximum demand/Connected load

(iv)Average load: The average of loads occurring on the power station in a given period (day or month or year) is known as average load or average demand.

Daily average load = No. of units (kWh) generated in a day/24 hours

Monthly average load = No. of units (kWh) generated in a month/Number of hours in a month

Yearly average load =No. of units (kWh) generated in a year/ 8760 hours

(v) Load factor: The ratio of average load to the maximum demand during a given period is known as load factor i.e.,

Load factor =Average load/Max. demand
If the plant is in operation for T hours,
Load factor = Average load ×T/ Max. demand ×T
=Units generated in T hours/ Max. demand ×T hours

(vi) Diversity factor: The ratio of the sum of individual maximum demands to the maximum demand on power station is known as diversity factor i.e.
Diversity factor = Sum of individual max. demands/Max. demand on power station.

(vii) Plant capacity factor: It is the ratio of actual energy produced to the maximum possible energy that could have been produced during a given period i.e.
Plant capacity factor = Actual energy produced/ Max. energy that could have been produced
= Average demand×T/ Plant capacity ×T
= Average demand/ Plant capacity
Thus if the considered period is one year,
Annual plant capacity factor = Annual kWh output/Plant capacity×8760

(viii) Plant use factor: It is ratio of kWh generated to the product of plant capacity and the number of hours for which the plant was in operation i.e.
Plant use factor = Station output in kWh/ Plant capacity×Hours of use

Units Generated per Annum

It is often required to find the kWh generated per annum from maximum demand and load factor.
The procedure is as follows:
Load factor =Average load/ Max. demand
∴ Average load = Max. demand×L.F.
Units generated/annum = Average load (in kW)×Hours in a year
= Max. demand (in kW)×L.F.×8760

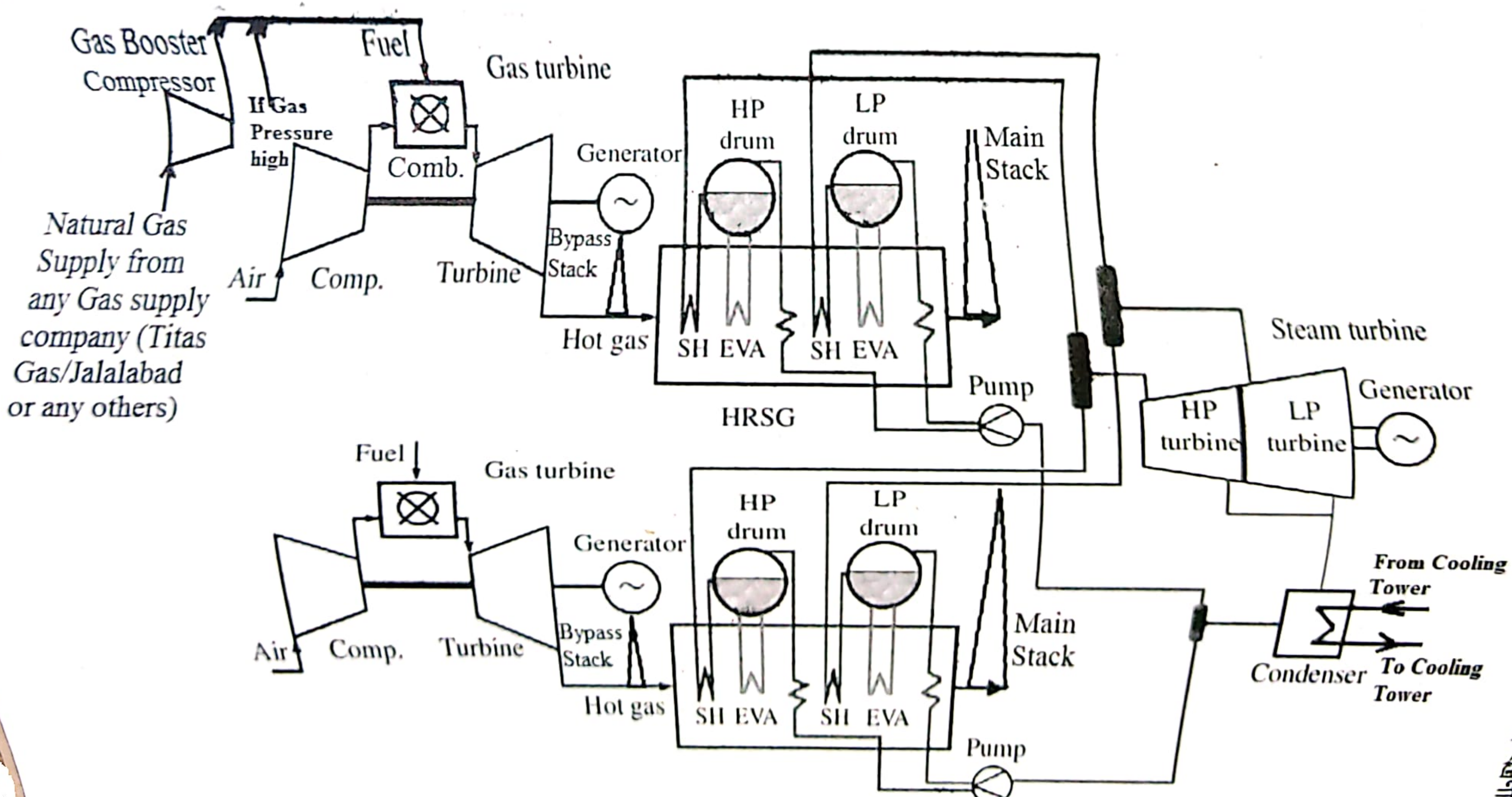


Fig. Schematic Diagram of a Combined Cycle Power Plant

Combined Cycle Power Plant:

বাংলাদেশে বেশ কিছু Combined Cycle Power Plant আছে। যেমনঃ BPDB এর আওতাধীন ঘোড়াশাল বিদ্যুৎকেন্দ্র, আশুগঞ্জ পাওয়ার প্লান্টের কিছু ইউনিট, নর্থওয়েস্ট পাওয়ার কোম্পানীর সিরাজগঞ্জ, ভেড়ামারা, খুলনা প্লান্টে, বেসরকারি বিবিয়ানা, হরিপুর, মেঘনাঘাট, সেম্পকর্প পাওয়ার প্ল্যান্টগুলো Combined Cycle-এ চলে। আমরা জানি একটা কম্বাইন্ড সাইকেল পাওয়ার প্ল্যান্টে দুইটা সাইকেল থাকে। যেমনঃ Gas Turbine (Brayton/ Joule Cycle) এবং Steam Turbine (Rankine Cycle)। গ্যাস টার্বাইনে Combustion-এর জন্য Air এবং Gas লাগবে। আমরা পরিবেশের Air-কে একটা Filter House-এর ভিতর দিয়ে Filter করে Air compressor-এর suction-এ দিব এবং এই Air compressor Atmospheric pressure-এ Air suction করবে আর Delivery তে 15-20bar Pressure-এ Combustor/combustion chamber-এ দিবে। এই ধরনের Air compressor-এ ১৫ থেকে ২০ টা (বেশ কয়েকটা পাওয়ার প্ল্যান্টে ১৭ টা Stage আছে) Stage থাকে এবং এগুলো Axial টাইপ হয়ে থাকে। Air এর pressure বাড়ার সাথে সাথে Air-এর Temperature-ও বেড়ে যায় এবং এই তাপমাত্রা মোটামুটি 370-390 ডিগ্রী সেলসিয়াসের মত হয়। Combustion- এর জন্য Air-এর পাশাপাশি Natural Gas supply দিতে হয়। এই গ্যাস বাংলাদেশে বিভিন্ন কোম্পানির মাধ্যমে বিদ্যুৎ কেন্দ্রগুলোতে সাপ্লাই দিয়ে থাকে। যেমনঃ তিতাস গ্যাস, পশ্চিমাঞ্চল গ্যাস কোম্পানি ইত্যাদি। এসব গ্যাস সরবরাহ কোম্পানির গ্যাসের লাইন প্রেসার 10 থেকে 13bar পর্যন্ত পাওয়া যায়। কিন্তু combustion chamber-এ গ্যাসের প্রেসার 35-40bar প্রয়োজন হয়। তাই বিদ্যুৎ কেন্দ্রগুলোতে একটা গ্যাস compressor বসানো হয়। এই গ্যাস compressor গ্যাসের লাইন প্রেসারকে 10-13bar থেকে 35-40bar-এ উন্নীত করে। এই ধরনের compressor-কে Booster compressor বলা হয়। বিদুৎ কেন্দ্রে এগুলোকে Fuel Gas Compressor (FGC) বা Natural Gas Compressor (NGC) বলে। যেসব ক্ষেত্রে সরাসরি গ্যাস ফিল্ডগুলো থেকে গ্যাস সরবরাহ করা হয় সেসব ক্ষেত্রে গ্যাসের প্রেসার অনেক বেশি হওয়ায় আলাদা Gas Compressor লাগে না। এই Gas এবং Air-এর মিশ্রণ সঠিকভাবে হওয়ার জন্য আধুনিক অনেক কম্বাসটরেই এখন Pre-mixing chamber থাকে। এর ফলে NOx, SOx তৈরির সম্ভাবনা অনেক কমে যায়। একটা Gas Turbine-এর Combustion তাপমাত্রা ১৪০০-১৮০০ ডিগ্রী সেলসিয়াস পর্যন্ত হয় এবং এই তাপমাত্রা Turbine-এর inlet-এ ১২০০-১০০০ ডিগ্রী সেলসিয়াসে নেমে আসে। Turbine-এ workdone শেষে exhaust তাপমাত্রা ৫৬০-৬০০ ডিগ্রী সেলসিয়াস পাওয়া যায়। এই অতি তাপমাত্রার exhaust Gas-কে কাজে লাগিয়ে একটা Boiler বা Steam Generator-এ স্টীম তৈরি করে Steam Turbine চালানো হয়। এই ধরনের Steam Generator-কে Heat Recovery Steam Generator (HRSG) বলে। আর

একটা cycle-এর exhaust-কে কাজে লাগিয়ে আরেকটা cycle চালানো হয় বলেই একে combined cycle power plant বলে। এই steam turbine-কে আরো বেশি efficient করতে turbine-কে High Pressure, Intermediate Pressure এবং Low Pressure Turbine-এ ভাগ করা হয়ে থাকে। এতে করে High Pressure Turbine-এর exhaust-কে সরাসরি Condenser-এ না পাঠিয়ে আরো একটা Intermediate Pressure Turbine চালানো হয়। একইভাবে Low Pressure Turbine চালানো হয়। এইসব ভিন্ন প্রেসারের turbine-এ Superheater, Reheater থাকে। Main Steam Generation হয় Evaporator-এ। Condenser-এ exhaust Steam-কে Condense করার জন্য Cooling Tower-থেকে অপেক্ষাকৃত কম তাপমাত্রার ঠান্ডা পানি সরবরাহ করা হয়। কোন কোন ক্ষেত্রে Cooling Tower-এর পরিবর্তে নদী থেকে সরাসরি পানি দিয়ে Condenser-এর মাধ্যমে Condense করে সেই পানিকে আবার নদীতে দেওয়া হয়। এই পদ্ধতিকে Once through process বলে। গ্যাস ও স্টীম টার্বাইনের পৃথক জেনারেটরের আউটপুটকে টান্সফরমারের মাধ্যমে ২৩২কেভি বা ১৩২ কেভিতে রূপান্তর করে জাতীয় গ্রিডে প্রেরণ করা হয়।

উপরের schematic diagram-এ আমরা দেখতে পাচ্ছি সেখানে দুইটা Gas Turbine Cycle, দুইটা HRSG এবং একটা Steam Turbine Cycle। অনেক ক্ষেত্রে combined cycle power plant-এ একটা Gas Turbine Cycle, একটা HRSG এবং একটা Steam Turbine Cycle থাকে।

একটা পাওয়ার প্ল্যান্টে কি কি Auxiliary System বা Support System থাকেঃ - Water Intake System

- Water Treatment System
- Air Compressor for Service air and Instrument air
- Cooling Tower
- Cooling Water System
- Turbine Lube Oil System
- Turbine Control Oil system
- Generator Cooling System
- Transformers
- Switch Yard
- Main Control Room
- MCC Rooms
- Emergency Diesel Generator
- HVAC System
- Fire Fighting System

43. What are the combustor types?

Answer: Three types of combustion systems are currently used: the silo type, the multiple canular, and the annular ring.

The silo type system uses a large single chamber or dual chambers that houses all of the nozzles, atomizing air connections, spark plug ignition systems, and flame detectors.

The multiple-canular type system uses a number of smaller combustion chambers arranged in an annular configuration around the inlet of the turbine. Each combustion chamber, or can, contains its own nozzle(s) and atomizing air connections. The chambers are interconnected to ensure uniform combustion in each chamber.

The annular ring system uses a single combustion chamber that is arranged in an annular configuration around the inlet of the turbine. The chamber contains all of the nozzles, atomizing air connections, spark plug ignition systems, and flame detectors.

44. What are the performance parameters of gas turbine?

Answer: Gas turbine generator performance is characterized by generator output and heat rate.

Generator output is the electrical generation of the turbine generator and typically is measured at the generator terminals. Generator output is measured in units of kilowatts or megawatts.

Heat rate is the ratio of heat consumption to generator output and is usually expressed in units of British thermal units per kilowatt-hour (Btu/kWh).

Other principal gas turbine performance parameters are listed below, with their English units of measure in parentheses:

• Compressor inlet temperature (°F),
• Compression ratio,
• Turbine inlet temperature (°F),
• Exhaust temperature (°F),
• Exhaust gasflow(lb/h),

- Exhaust heat (Mbtu/h),
- Inlet pressure loss (in. H_20), and
- Exhaust pressure loss (in. H_20).

45. What are the techniques for controlling NO_X?

Answer: The basic techniques for controlling NO_X emissions from gas turbines: steam or water injection, dry low NO_X (or lean pre-mix combustion) and SCR (selective catalytic reduction).

46. What is alignment?

Answer: Alignment is a method or procedure by which shafts of machines such as motors and turbines are connected to a generator or pump in proper alignment.

Improper alignment leads to increase of stresses in the shafts and thus on the equipment, which might result in break down of the machine.

47. What are the methods of alignment?

Answer: These are the methods of alignment,

i) Visual Line-Up.
ii) Rim and Face.
iii) Straightedge/Feeler Gauge.
iv) Cross Dial.
v) Reverse Dial.
vi) Laser.

48. What is sealing?

Answer: To minimize the loss of fluid in a system something must be provided to seal the point where shafts or stem pass through the housing or bodies of the equipment. The sealing equipment needs the proper movement of the shaft or the stem.

49. What is mechanical seal?

Answer: A mechanical seal is a device that helps to join systems or mechanisms together by preventing leakage, containing pressure, or excluding contamination. It's simply a method of containing fluid within a vessel (typically pumps, mixers, etc.) where a rotating shaft passes through a stationary

housing or occasionally, where the housing rotates around the shaft.

50. What are the main components of mechanical seal?

Answer: Every mechanical seal has these five basic components.

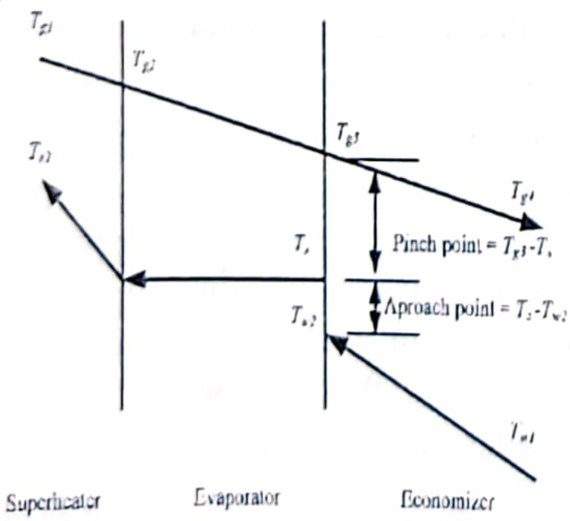
- One ring (usually the seal face) circulating synchronously with the rotating part (shaft).
- Secondary seal (usually O-ring) between shaft and ring.
- A stationary ring (usually the stationary seat) arranged in the stationary part (casing).
- Secondary seal (usually O-ring) between these parts.
- Spring for the seal face.

51. What is the Pinch Point and Approach pont of a HRSG?

Answer: Pinch Point (T_{pp}): The pinch point is the difference between the gas temperature leaving the evaporator and the temperature of saturated steam.

So, $T_{pp} = T_{g3} - T_s$

Approach Point (T_{Ap}): The approach point is the difference between the saturated steam temperature leaving the evaporator and the temperature of water entering the evaporator. So, $T_{Ap} = T_s - T_{w2}$



52. Tell some manufacturing company name Gas Turbine.

Answer: Alstom Power, General Electric (GE), Mitsubishi (MHI/MHPS) and Siemens Power Generation.

53. What is the possible thermal efficiency of a Combined Cycle Power Plant (CCPP)?

Answer: 55-61%

54. What are the environment boundings of a power plant?

Answer: 1. Noise Control, 2. Water Treatment System, 3. Airborne Emissions

55. What are the types of thrust bearings?

Answer:

1. Babbitt-faced collar bearings
2. Tilting pivotal pads
3. Tapered land bearings
4. Rolling-contact (roller or ball) bearings

56. What are the types of turbine seals?

Answer:

1. Carbon rings fitted in segments around the shaft and held together by garter or retainer springs.
2. Labyrinths mated with shaft serrations or shaft seal strips.
3. Water seals where a shaft runner acts as a pump to create a ring of water around the shaft. Use only treated water to avoid shaft pitting.
4. Stuffing box using woven or soft packing rings that are compressed with a gland to prevent leakage along the shaft.

Nuclear Power Plant

1. **How much energy is generated from a Nuclear Fission Reaction?**

Answer: 250MeV

2. **1 Million Electron Volt = _ Joule?**

Answer: 1.6×10^{-19}J=1eV

$\therefore 1.6 \times 10^{-13}\text{J} = 1\text{MeV}$

3. **What type of reactor will be used at RNPP?**

Answer: VVER (Water-cooled Water-moderated Power Reactor) reactor plant of AES –2006 (VVER –1200/523) technology.[2]

4. **VVER – এর অর্থ কি?**

Answer: Water-Water Energetic Reactor (Russian: vodo-vodyanoi energetichesky reaktor)

5. **Water-Water দুইবার বলার কারণ কি?**

Answer: Water-cooled Water-moderated

6. **Pressurizer কেন ব্যবহার করা হয়?**

Answer: আমরা জানি, একটা pressurized water reactor (PWR) এ মূল নিউক্লিয়ার বিক্রিয়া থেকে তাপ শোষণের জন্য একটা Cooling system থাকে। আর এই সিস্টেমটাকে Primary circuit বা reactor coolant system বলে। এই circuit এর পানি অবশ্যই boil হতে দেওয়া যাবে না। অন্যভাবে বললে, Primary circuit এর পানি সর্বদায় liquid state এ থাকতে হবে। অথচ Primary circuit এর পানির ইনলেট ও আউটলেট তাপমাত্রা যথাক্রমে প্রায় ২১৫ ডিগ্রী সেলসিয়াস থেকে প্রায় ৩২০ ডিগ্রী সেলসিয়াসের মত। এই তাপমাত্রায় সাধারণ চাপে কখনোই এই পানিকে liquid state এ রাখা সম্ভব নয় যদি না সেখানে boiling point এর চেয়ে বেশি চাপ প্রয়োগ করা হয়। আর এই আলাদা অতিরিক্ত চাপের তৈরির জন্যই Pressurizer ব্যবহার করা হয়।

A Pressurizer is a component of a pressurized water reactor. The basic design of the pressurized water reactor includes a requirement that the coolant (water) in the reactor coolant system must not boil. Put another way, the coolant must remain in the liquid state at all times, especially in the reactor vessel. To achieve this, the coolant in the reactor coolant system is

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[2] https://en.wikipedia.org/wiki/Rooppur_Nuclear_Power_Plant

maintained at a pressure sufficiently high that boiling does not occur at the coolant temperatures experienced while the plant is operating or in an analyzed transient. To pressurize the coolant system to a higher pressure than the boiling point of the coolant at operating temperatures, a separate pressurizing system is required. That is the function of the pressurizer.[3]

7. Cooling Tower Types?

Answer: According to the method adopted to circulate the air, cooling towers may be classified as:

- Natural draft cooling towers
- Mechanical draft cooling towers (Induced draft, Forced draft).

8. What type of cooling tower is preferable? Why?

Answer: এটা নির্ভর করে কোন ক্ষেত্রে এটা ব্যবহার করা হবে তার উপর। সাধারণত ইন্ডাস্ট্রির জন্য Mechanical draft (Induced draft) ব্যবহার করা হয়। এছাড়া সাধারণ স্বল্প মেয়াদী পাওয়ার প্ল্যান্টগুলোতে Mechanical draft (Induced draft) ব্যবহার করা হয়। যেসব পাওয়ার প্ল্যান্ট দীর্ঘমেয়াদী এবং বেশি বড় সেগুলোতে Natural draft cooling tower ব্যবহার করা হয়। Natural draft cooling tower এর Installation Cost বেশি হলেও দীর্ঘমেয়াদী হওয়ায় এটি সাশ্রয়ী হয় এবং বেশি ক্যাপাসিটিতে সার্ভিস দিতে সক্ষম। আবার HVAC সিস্টেমেও Mechanical draft ব্যবহার করা হয়। উপরে যেসব ক্ষেত্রে Mechanical draft ব্যবহার করা হয় বলা হয়েছে সেসব ক্ষেত্রে Induced draft, Forced draft দুই প্রকারই ব্যবহার করা হয় তবে বেশি ব্যবহার করার কারণ হলো এটি Cost effective, Low power consuming এবং Efficient.

9. What is the function of moderator?

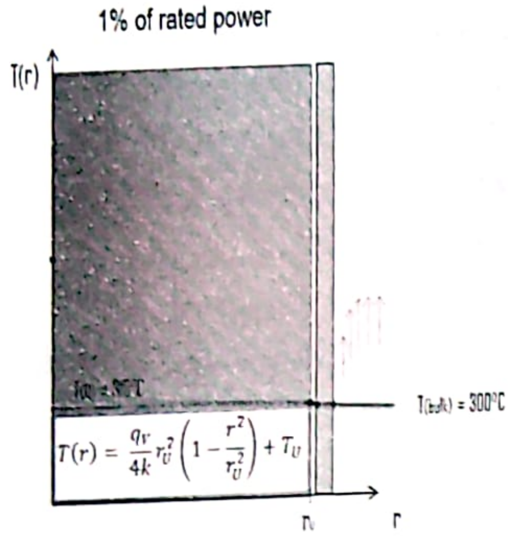
Answer: A moderator is a material used in a nuclear reactor to slow down the neutrons produced from fission. By slowing the neutrons down the probability of a neutron interacting with Uranium-235 nuclei is greatly increased thereby maintaining the chain reaction.

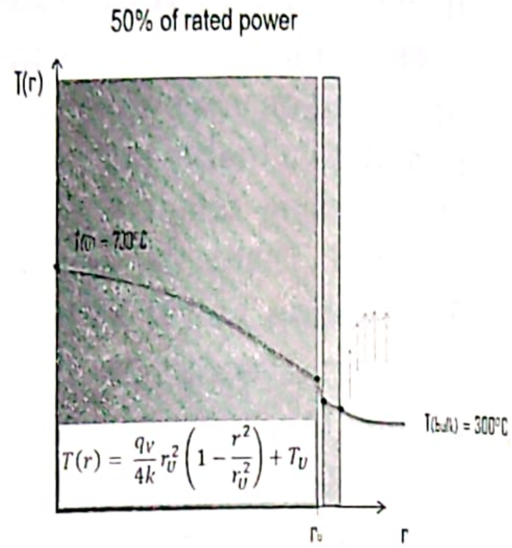
10. Temperature graph of fuel rod?

Answer: If the temperature distribution is T(r),

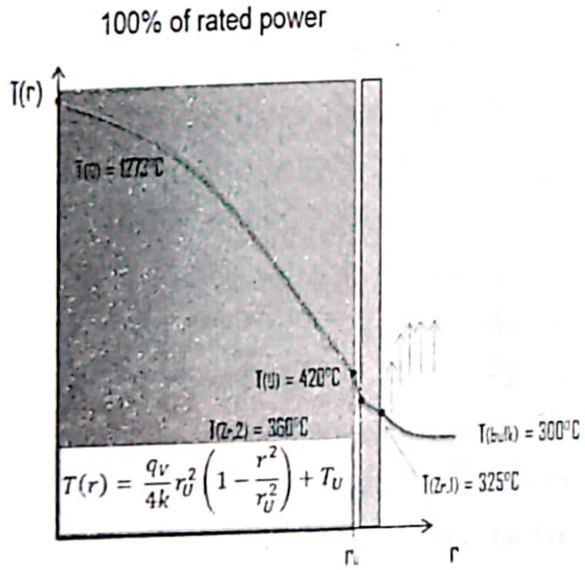
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[3] https://en.wikipedia.org/wiki/Pressurizer





The temperatures at the surface of the fuel pellet $= T_U$, the fuel pellet radius $= r_U$ the averaged material's conductivity is k ,the linear heat rate is q_L and the volumetric heat rate is q_V.



11. Where the maximum temperature is found in a fuel rod?

Answer: Center of the fuel rod or fuel pallet.

12. Which materials are used as moderator and control rod?

Answer: Moderator: a. Light Water, b. Heavy Water, c. Graphite

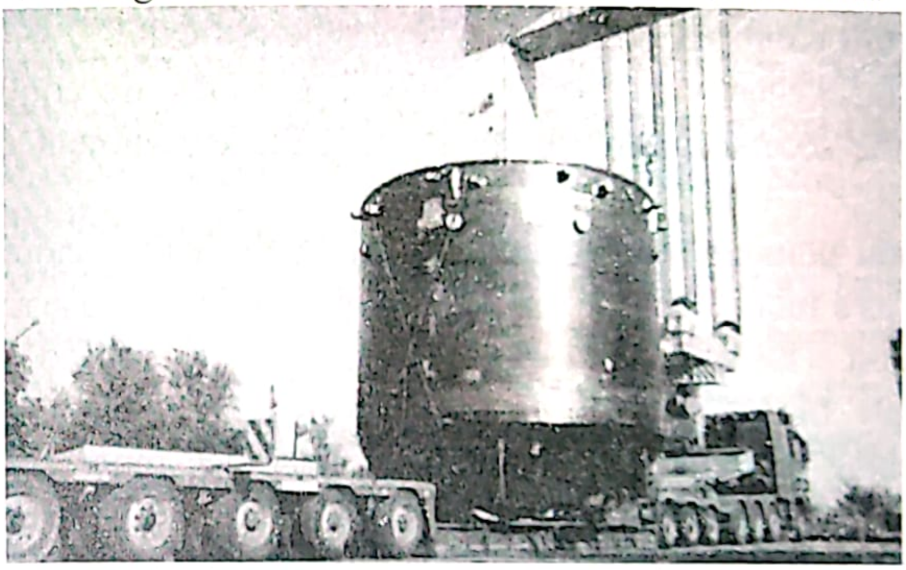
Control Rod: a. Boron, b. Cadmium

13. Refueling cycle interval of a nuclear power plant?

Answer: 12 to 18 months.

14. What is core catcher?

Answer: A core catcher is a device provided to catch the molten core material - corium -of a reactor in the unlikely event of a meltdown, preventing it from escaping the containment building. The first such device was installed at the Tianwan nuclear power plant in China, which was constructed by Russia. A core catcher is made from a special concrete ceramic or steel to prevent material from trickling through; it is also a cooling mechanism to cool down the core material.



The core catcher for the second VVER under construction at Ostravets in Belarus (Image: AEM-Technology)

15. Which thermodynamic cycle is associated with nuclear power plant?

Answer: Rankine Cycle

16. Coolant pressure & inlet-outlet temperature of Rooppur Nuclear Power Plant (RNNP).

Answer: Pressure- 16.2±0.3MPa

Inlet Temperature- 298.2°C

Outlet Temperature- 328.6°C

17. Why a reactor never be an atomic bomb?

Answer: There are two main fundamental differences between the design of an atomic bomb, and the design of a nuclear reactor.

An atom bomb is an uncontrolled fission chain reaction, that releases exorbitant amounts of energy quickly. The design of a nuclear reactor includes control rods. The control rods are placed in the core to control the fission reaction. Control rods do this by absorbing neutrons, which decreases the multiplication factor. The more control rods in the core, the lower the criticality, thus there will be less neutrons available for fission. An atom bomb is designed to maintain all the neutrons produced, making it always supercritical.

One difference is the way the fission reactions are controlled and the second difference stems from the enrichment of the fuel.

Natural uranium, the uranium found in the earth, cannot be used as a fuel because it is not reactive enough to cause a chain reaction. This is because natural uranium is composed almost entirely of U^{238}, which is a relatively stable element. By enriching it with U^{235}, the uranium becomes more reactive, which increases the production factor. While both fuel for a reactor and fuel for an atomic bomb are enriched, a reactor's fuel is only enriched around 4 to 5 percent. Whereas an atomic bomb is enriched to about 90 percent. This makes the multiplication factor much larger in a bomb than a reactor, which signifies a greater number of available neutrons. The fuel used in a reactor is not capable of causing an explosion.

18. What is the significance of delayed neutron?

Answer: While the most of the neutrons produced in fission are prompt neutrons, the delayed neutrons are of importance in the reactor control. In fact the presence of delayed neutrons is perhaps most important aspect of the fission process from the viewpoint of reactor control. The term 'delayed' in this context means, that the neutron is emitted with half-lifes, ranging from

few milliseconds up to 55s for the longest-lived precursor ^{87}Br. These neutrons have to be distinguished from the prompt neutrons, which are emitted immediately (on the order of 10-14s) after a fission event from a neutron-rich nucleus. Despite the fact the amount of delayed neutrons is only approximately tenths of percent of the total amount, the timescale in seconds plays the extremely important role.

১৯. এখন পর্যন্ত বিশ্বে কতটি নিউক্লিয়ার দুর্ঘটনা ঘটেছে?

Answer: Serious nuclear accidents have been few and far between but their stories will help prevent future catastrophes.

Fukushima Daiichi

Fukushima, Japan, March 2011

The earthquake and tsunami that struck eastern Japan on March 11, 2011, caused a serious accident at the Fukushima Dai-ichi nuclear power plant on the northeastern coast of Japan.

How did it happen?

The earthquake cut off external power to the reactors. tsunami, which reached levels more than twice as high as the plant was designed to withstand, disabled backup diesel generators, crippling the reactor cooling systems. Battery power was quickly exhausted, and overheating fuel in the plant's operating reactor cores led to hydrogen explosions that severely damaged three of the reactor buildings. Fuel in three of the reactor cores melted, and radiation releases from the damaged reactors contaminated a wide area surrounding the plant and forced the evacuation of nearly half a million residents.

Chernobyl

Chernobyl, Ukraine (former Soviet Union), April 26, 1986

Chernobyl is considered the world's worst nuclear disaster to date. It occurred on April 26, 1986, when a sudden surge in power during a reactor systems test resulted in an explosion and fire that destroyed Unit 4. Massive amounts of radiation escaped and spread across the western Soviet Union and Europe. As a result of the disaster, approximately 220,000 people had to be relocated from their homes.

How did it happen?

Unit 4 was to be shut down for routine maintenance. A test was conducted to determine the plant equipment's ability to provide sufficient electrical power to operate the reactor core cooling system and emergency equipment during the transition period between a loss of main station electrical power supply and the start-up of the emergency power supply. Workers did not implement adequate safety precautions or alert operators to the electrical test's risks. This lack of awareness led the operators to engage in actions that diverged from safety procedures. Consequently, a sudden power surge resulted in explosions and nearly complete destruction of the reactor. The fires that broke out in the building contributed to the extensive radioactive releases.

Three Mile Island

Middletown, Pennsylvania, USA, March 28, 1978

The partial meltdown at Three Mile Island Unit 2 is considered the most serious nuclear accident in U.S. history, although it resulted in only small radioactive releases.

How did it happen?

The accident began with failures in the non-nuclear secondary system, followed by a human-operated relief valve in the primary system that stuck open, which allowed large amounts of nuclear reactor coolant to escape. Plant operators' initial failure to correctly identify the problem compounded it. In particular, a hidden indicator light led to an operator manually overriding the automatic emergency cooling system because he mistakenly believed that too much coolant water in the reactor had caused the steam pressure release. Eventually the reactor was brought under control, although the full extent of the accident was not understood until later.

Enrico Fermi Unit 1

Frenchtown Charter Township, Michigan, USA, October 5, 1966

Coolant flow blockage in two fuel channels led to the partial meltdown of two fuel assemblies at Fermi Unit 1.

How did it happen?

Fermi Unit 1 was the nation's first and only commercially operating liquid metal fast breeder reactor. Vibrations caused a component within the reactor vessel to loosen, which blocked coolant flow when hydrodynamic forces carried it up the fuel subassemblies' inlet nozzle. Workers did not notice what had occurred until core temperature alarms sounded. Several fuel rod subassemblies reached temperatures of up to 700 degrees Fahrenheit, causing them to melt. After the reactor was shut down for repairs, it was returned to partial operation periodically until 1972, but it was never again fully operational. It was officially decommissioned in 1975.

SL-1

Idaho Falls, Idaho, USA, January 3, 1961

The withdrawal of a single control rod caused a catastrophic power surge and steam explosion at the SL-1 boiling water reactor that killed all the workers on duty at the time.

How did it happen?

On January 3, 1961, workers were in the process of reattaching to their drive mechanisms control rods they had disconnected earlier that day to enable test equipment to be inserted in the reactor core. They lifted the central control rod 20 inches, instead of the four inches that was required. This error caused the reactor to go critical and its power to surge 6,000 times higher than its normal level in less than a second. As a result, nuclear fuel vaporized and a steam bubble was created. The steam bubble expanded so quickly that it pushed water above it against the reactor vessel, which caused it to jump out of its support structure. It hit an overhead crane and then returned to the reactor vessel. In the process, all of the water and some of the fuel was released from the reactor vessel. All three workers

on duty received lethal doses of radiation, in addition to trauma from the explosion.[4]

20. Types of nuclear waste generated from nuclear power station

Answer: The nuclear wastes produced from nuclear power station are classified into three categories (i.e. **gas, liquid and solid wastes**).

The waste treatment process includes filtering, clean-up, storage, decay and dilution depending on the characteristics of the wastes and its radioactivity. When the radioactivity of the waste has diminished to a very low level, it would be released to the environment on condition that it would not exceed the permissible limit. The gaseous waste is released to the environment after treatment via the stack. The liquid waste is mixed and diluted with the effluent from the plant after treatment before discharging to the sea/river.

Solid nuclear wastes produced by the nuclear power station will not be released to the environment.

There are three types of solid nuclear wastes classified in terms of its radioactivity (i.e. low, intermediate and high-level wastes).

Low-level waste (LLW) consists of daily refuse such as paper, gloves, plastic containers, disposable overalls and overshoes with low radioactive contamination. LLW is compressed into steel drums, sealed and stored temporarily at the nuclear power station and eventually be transported to the repository for disposal.

Intermediate-level waste (ILW) consists of radioactive resin and chemical sludge, spent filter cartridges etc. collected from waste treatment process and maintenance work. ILW is solidified by mixing it with sand/cement and then poured into concrete drums. The ILW would be transported to the

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[4] https://www.ucsusa.org/resources/brief-history-nuclear-accidents-worldwide

repository for burial eventually after temporary storage at the nuclear power station.

The used fuel assemblies taken out from the reactor (spent fuel) during the refuelling outage are regarded as **High-level waste (HLW)**. The HLW contains highly-radioactive fission products and radionuclides with long-lived radioactivity. The spent fuels would be stored and cooled in the 'spent fuel pool' inside the containment building for about 10 years to allow for the radioactive decay of its nuclides and removal of the residual heat. The spent fuels would then be arranged for either reprocessing or direct deep underground burial in repository for HLW.

21. How energy is generated in nuclear power plant?

Answer: In Nuclear power plant energy is released by nuclear fission. Nuclear fission is the process in which heavy nucleus such as ${}^{233}_{92}U$, ${}^{235}_{92}U$, and ${}^{239}_{94}Pu$ when bombarded by certain particles (protons, neutrons, X-rays), the heavy nucleus will split into two or more smaller nuclei, ejection of two or more neutrons and liberation of vast amount of energy. Therefore this split of heavy nucleus into two or more smaller nuclei is called fission process.

22. What are the particles used in nuclear fission?

Answer: High energy alpha particles, protons, deuterons, X-rays as well as neutrons can be used for the fission process. However neutrons are chosen because neutrons are electrically neutral in nature and thus they do not require high kinetic energy to overcome electrical repulsion from the positively charged nuclei and can participate in fission reaction.

23. What is fertile material and fissile material?

Answer : Not all the Uranium extracted from the ore can be used as fuel for plant for carrying out the fission reaction. Natural uranium consists of 99.3% of ${}^{238}_{92}U$ and only 0.7% of ${}^{235}_{92}U$. Out of these isotopes, ${}^{235}_{92}U$ is used in fission reaction

Materials such as $^{233}{}_{92}U$, $^{235}{}_{92}U$,and $^{239}{}_{94}Pu$ are called fissile material or fissionable materials. This material is required to carry out the fission reaction.

Materials such as $^{238}{}_{92}U$ and $^{232}{}_{90}Th$ which occur in nature are called fertile materials. Fissile materials ($^{233}{}_{92}U$, $^{239}{}_{94}Pu$) can also be artificially be produced using fertile materials.

24. What is chain reaction and how it is controlled in nuclear reactor?

Answer : In fission reaction during every stage two or more daughter nuclei is released, two or more neutrons and vast energy is released. Each neuron produced further participate in fission reaction and results in release of more neutrons, this reaction continues results in nuclear explosion. However in nuclear reactor the excess neutrons produced will be absorbed using moderator and control rods allowing only one neutron per fission to carryout further chain reaction.

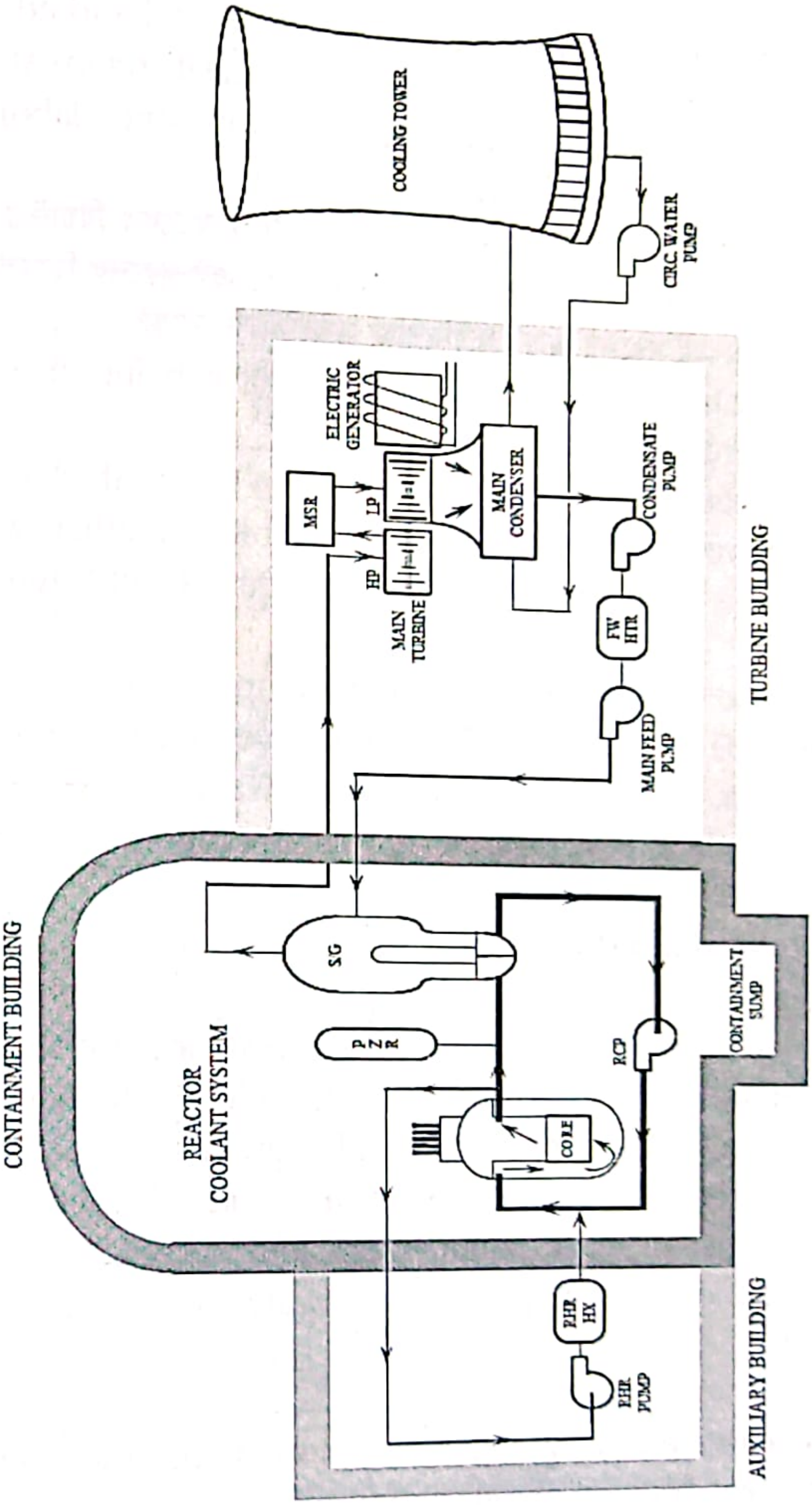
25. What is half life and its significance?

Answer : The half life or half life period is defined as the time required for the radio-activity of an isotope to reduce to half of its original value. Radioactive material is dangerous because of its half life periods. Half life for radio active materials such as uranium, plutonium lasts for thousands of years.When the radio activity is exposed to the environment, the element will exist in the environment for thousands of years before it decays results in making the environment (land, water, habitation) radioactive for thousands of decades.

26. How coal energy is comparable with nuclear energy?

Answer: One of the main attention for nuclear fuel is the huge amount of energy that can be released from a small quantity of active nuclear fuel. The energy obtainable by completely using 1 kg of Uranium would give energy equivalent 3000 tons of high grade coal i.e. Uranium has three millions times the energy of coal.

27. Layout of a PWR Plant.
Answer:



The major structures at a pressurized water reactor plant are:

• **The containment building**, which houses the reactor and its high pressure steam generating equipment;

• **The turbine building,** which houses the steam turbines, condensers, and the electrical generator; and

• **The auxiliary building,** which houses normal and emergency support systems (such as the residual heat removal (RHR) system, fuel handling and storage equipment, laboratories, maintenance areas, and the control room).

রূপপুর পারমাণবিক বিদ্যুৎ কেন্দ্রে যে **VVER-1200** মডলের রিয়াক্টর চালু হতে যাচ্ছে সেটিও **Pressurized Water Reactor.** এই ধরনের রিয়াক্টর ব্যবহার করা হচ্ছে কারণ এই ধরনের রিয়াক্টরে নিম্নোক্ত সুবিধাগুলো আছেঃ

1. It is easy to operate because less power is being produced as the heat increases.

2. As the reactor core contains less fissile material, it makes the reactor more safer and more controllable. In other words, it contains less fissile material than the requirement to go prompt critical.

3. Since the primary and secondary loops are separate, water can never be contaminated by radioactive material in the main system loop. As a result, the secondary water will never mix to the primary loop water during normal operation, so there is no chance for contamination.

28. Layout of a BWR Plant.

Answer:

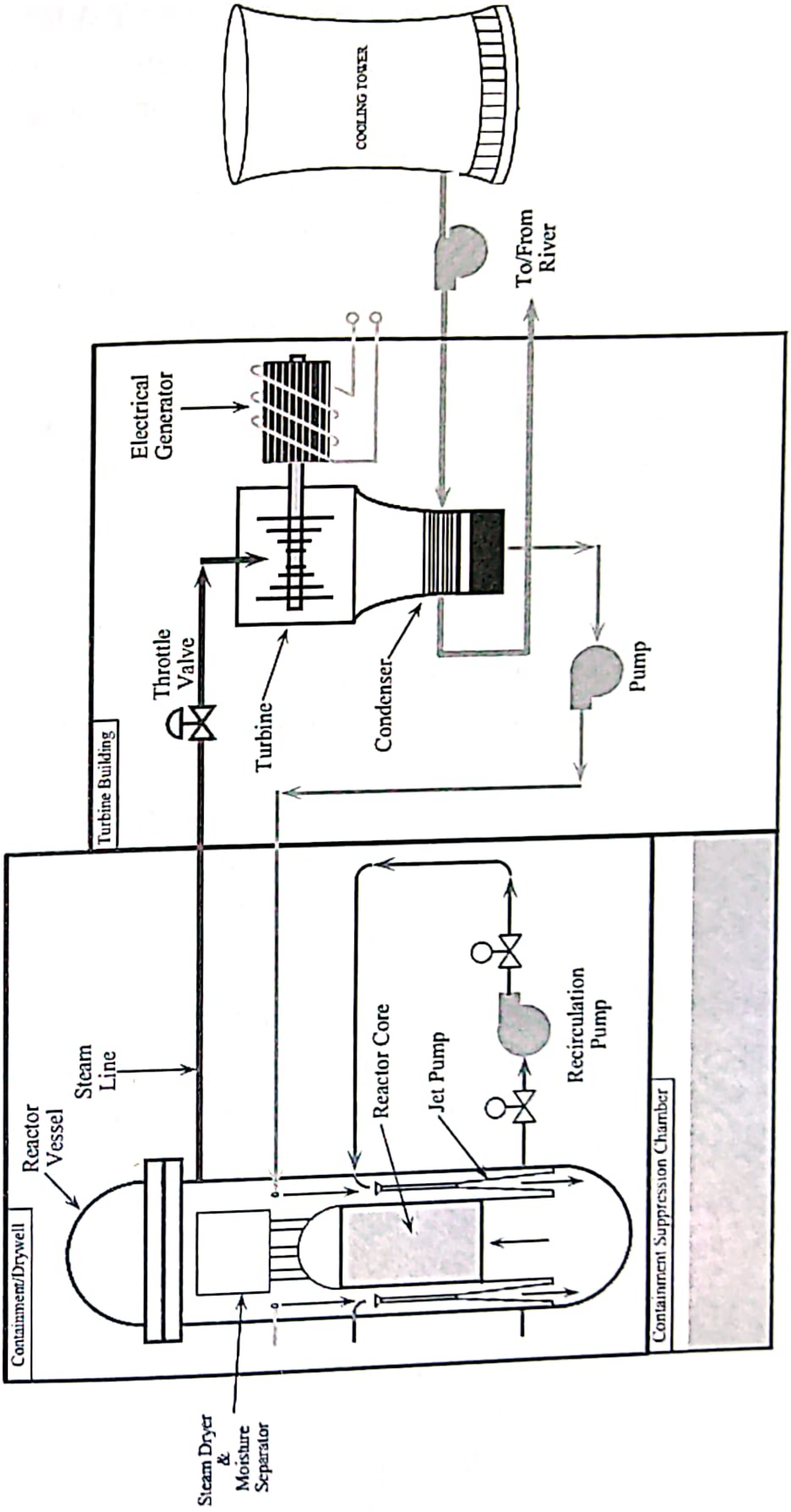
The major structures at a boiling water reactor plant are:

• **The primary containment**, which includes the suppression chamber, and houses the reactor and recirculation pumps;

• **The reactor building (secondary containment),** which surrounds the primary containment and serves many of the same functions as a pressurized water reactor's auxiliary building;

and

• **The turbine building,** this includes steam turbine, condenser, condensate extraction pumps and turbine auxilieries.


COOLING TOWER
To/From River
Electrical Generator
Throttle Valve
Turbine
Condenser
Pump
Turbine Building
Reactor Vessel
Steam Line
Reactor Core
Jet Pump
Recirculation Pump
Containment/Drywell
Containment Suppression Chamber
Steam Dryer & Moisture Separator

29. What are the similarities between PWR and BWR?

Answer: Both PWRs and BWRs use light water or normal water (H_2O) as the coolant and the neutron moderator. Furthermore, they both use enriched Uranium as fuel with cylindrical vessel types. The general structure of both reactors are also very similar, as they both consist of the main components of a nuclear reactor: a containment vessel, a reactor vessel, which houses the reactor core, and a steam generating turbine.

30. What are the differences between PWR and BWR?

Answer: The main difference between the PWR and BWR lies in the process of steam generation. A PWR generates steam indirectly by using two water circuits, a primary one and a secondary one. On the other hand, a BWR produces steam directly using a single water circuit.

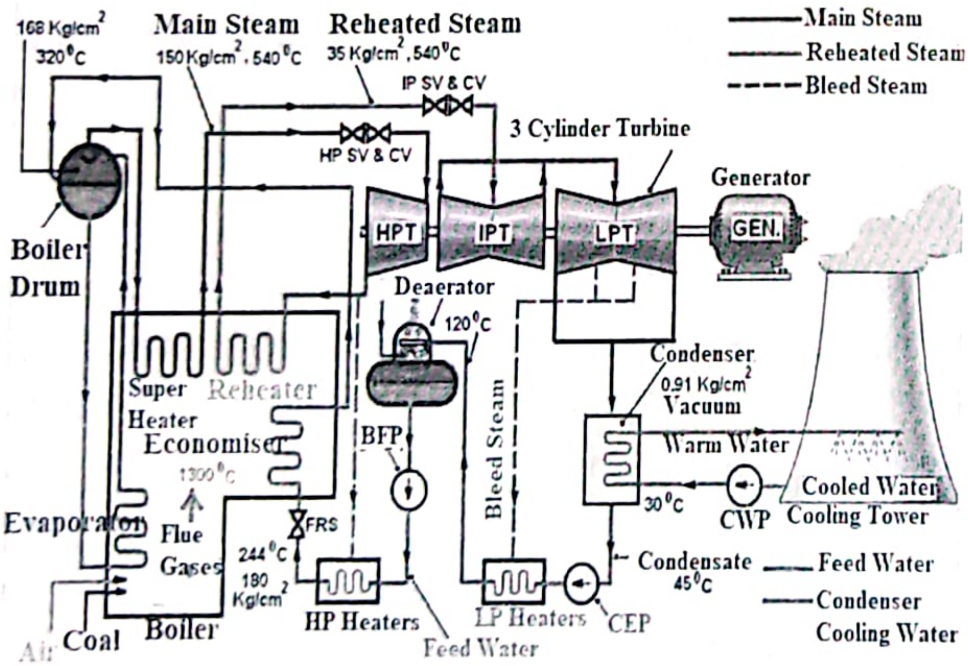
In a PWR heat from the reactor core is used to heat the primary reactor coolant at temperatures more or less 300°C. This water is kept liquid under high pressure. The heat from the primary water circuit is then transferred to the secondary circuit by way of the pressurized liquid. The secondary circuit then uses this heat to convert liquid water into steam for the turbine. The steam is later condensed and recycled.

In a BWR steam is directly produced by the boiling the water coolant. The steam is separated from the remaining water in steam separators positioned above the core and passed to the turbines. The steam is later condensed and recycled.

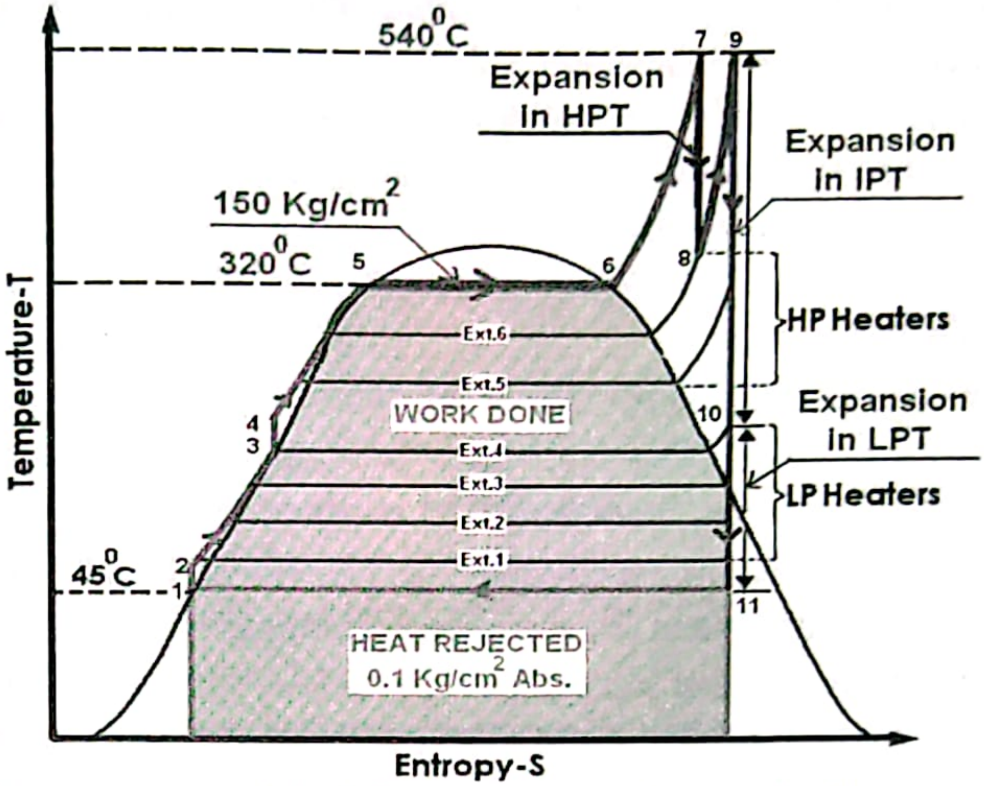
Coal Based Thermal Power Plant

- In a coal based thermal power plant, coal is transported from coalmines to the power plant by ships or by railway in wagons. Coal is unloaded from the ships to a moving conveyor belt. Coal from the mines is irregular shape. So it is taken to the crusher house and crushed to a size of below 30mm. From the crusher house the coal is either stored in dead storage (generally 40 days coal supply) which serves as coal supply in case of coal supply bottleneck or to the live storage (8 hours coal supply) in the raw coal bunker in the boiler house.
- Raw coal from the raw coal bunker is supplied to the Coal Mills by a Raw Coal Feeder. The Coal Mills or pulverizer pulverizes the coal to 200 mesh size. The powdered coal from the coal mills is carried to the boiler in coal pipes by high pressure hot air. The pulverized coal air mixture is burnt in the boiler in the combustion zone.
- Generally in modern boilers tangential firing system is used i.e. the coal nozzles/ guns form tangent to a circle. The temperature in fire ball is of the order of 1300^0C-1500^0C. The boiler is a water tube boiler hanging from the top. Water is converted to steam in the boiler and steam is separated from water in the boiler Drum.
- At the starting of power plant liquid fuel (HSD) is used for primay burning almost upto 25% load increase. Then coal burning is started.
- The saturated steam from the boiler drum is taken to the low Temperature Superheater, Platen Superheater and Final Superheater respectively for superheating. The superheated steam from the final superheater is taken to the High Pressure Steam Turbine (HPT).

- In the HPT the steam pressure is utilized to rotate the turbine and the resultant is rotational energy. From the HPT the out coming steam is taken to the reheater in the boiler to increase its temperature as the steam becomes wet at the HPT outlet.
- After reheating this steam is taken to the Intermediate Pressure Turbine (IPT) and then to the Low Pressure Turbine (LPT).
- The outlet of the LPT is sent to the condenser for condensing back to water by a cooling water system. This condensed water is collected in the Hotwell and is again sent to the boiler in a closed cycle. The rotational energy imparted to the turbine by high pressure steam is converted to electrical energy in the Generator.



Coal based thermal power plant works on the principal of Modified Rankine Cycle.



Components of Coal Fired Thermal Power Station:

- **Coal Preparation**

i) Fuel preparation system: In coal-fired power stations, the raw feed coal from the coal storage area is first crushed into small pieces and then conveyed to the coal feed hoppers at the boilers. The coal is next pulverized into a very fine powder, so that coal will undergo complete combustion during combustion process.

Pulverizer is a mechanical device for the grinding of many different types of materials. For example, they are used to pulverize coal for combustion in steam generating furnaces of fossil fuels power plants.

ii) Dryers: They are used in order to remove the excess moisture from coal mainly wetted during transport. As the presence of moisture will result in fall in efficiency due to incomplete combustion and also result in CO emission.

iii) Magnetic separators: Coal which is brought may contain iron particles. These iron particles may result in wear and tear. The iron particles may include bolts, nuts wire fish plates etc.

So these are unwanted and so are removed with the help of magnetic separators.

The coal we finally get after these above process are transferred to the storage site.

Purpose of fuel storage is two –

- Fuel storage is insurance from failure of normal operating supplies to arrive.
- Storage permits some choice of the date of purchase, allowing the purchaser to take advantage of seasonal market conditions. Storage of coal is primarily a matter of protection against the coal strikes, failure of the transportation system & general coal shortages.

There are two types of storage:

1. **Live Storage (boiler room storage):** Storage from which coal may be withdrawn to supply combustion equipment with little or no remanding is live storage. This storage consists of about 24 to 30 hrs of coal requirements of the plant and is usually a covered storage in the plant near the boiler furnace. The live storage can be provided with bunkers & coal bins. Bunkers are enough capacity to store the requisite of coal. From bunkers coal is transferred to the boiler grates.
2. **Dead storage**: It is the storage for future use. Mainly it is for longer period of time, and it is also mandatory to keep a backup of fuel for specified amount of days depending on the reputation of the company and its connectivity .There are many forms of storage some of which are –
   1. Stacking the coal in heaps over available open ground areas.
   2. Similar to the previous but placed under cover or alternatively in bunkers.
   3. Allocating special areas & surrounding these with high reinforced concerted retaking walls.

- **Boiler and auxiliaries**

A Boiler or steam generator essentially is a container into which water can be fed and steam can be taken out at desired pressure, temperature and flow. This calls for application of heat on the container. For that the boiler should have a facility to burn a fuel and release the heat. The functions of a boiler thus can be stated as:-

1. To convert chemical energy of the fuel into heat energy
2. To transfer this heat energy to water for evaporation as well to steam for superheating.

The basic components of Boiler are: -

1. Furnace and Burners
2. Steam and Superheating

a. Low temperature superheater
b. Platen superheater
c. Final superheater

- **Economiser**

It is located below the LPSH in the boiler and above pre heater. It is there to improve the efficiency of boiler by extracting heat from flue gases to heat water and send it to boiler drum.

Advantages of Economiser include:

1) Fuel economy: It is used to save fuel and increase overall efficiency of boiler plant.
2) Reducing size of boiler: As the feed water is preheated in the economiser and enter boiler tube at elevated temperature. The heat transfer area required for evaporation reduced considerably.

- **Air Pre heater**

The heat carried out with the flue gases coming out of economiser are further utilized for preheating the air before supplying to the combustion chamber. It is a necessary equipment for supply of hot air for drying the coal in pulverized fuel systems to facilitate grinding and satisfactory combustion of fuel in the furnace.

- **Reheater**

Power plant furnaces may have a reheater section containing tubes heated by hot flue gases outside the tubes. Exhaust steam from the high pressure turbine is rerouted to go inside the reheater tubes to pickup more energy to go drive intermediate or lower pressure turbines.

- **Steam turbines**

Steam turbines have been used predominantly as prime mover in all thermal power stations. The steam turbines are mainly divided into two groups: -

1. Impulse turbine
2. Impulse-reaction turbine

The turbine generator consists of a series of steam turbines interconnected to each other and a generator on a common shaft. There is a high pressure turbine at one end, followed by an intermediate pressure turbine, two low pressure turbines, and the generator. The steam at high temperature (536 ^{o}C to 540 ^{o}C) and pressure (140 to 170 kg/cm^2) is expanded in the turbine.

- **Condenser**

The condenser condenses the steam from the exhaust of the turbine into liquid to allow it to be pumped. If the condenser can be made cooler, the pressure of the exhaust steam is reduced and efficiency of the cycle increases. The functions of a condenser are:-

1) To provide lowest economic heat rejection temperature for steam.

2) To convert exhaust steam to water for reserve thus saving on feed water requirement.

3) To introduce make up water.

We normally use surface condenser although there is one direct contact condenser as well. In direct contact type exhaust steam is mixed with directly with D.M cooling water.

- **Boiler feed pump**

Boiler feed pump is a multi stage pump provided for pumping feed water to economiser. BFP is the biggest auxiliary equipment after Boiler and Turbine. It consumes about 4 to 5 % of total electricity generation.

Cooling tower

The cooling tower is a semi-enclosed device for evaporative cooling of water by contact with air. The hot water coming out from the condenser is fed to the tower on the top and allowed to tickle in form of thin sheets or drops. The air flows from bottom of the tower or perpendicular to the direction of water flow and then exhausts to the atmosphere after effective cooling.

The cooling towers are of four types: -

1. Natural Draft cooling tower
2. Forced Draft cooling tower
3. Induced Draft cooling tower
4. Balanced Draft cooling tower

Fan or draught system

In a boiler it is essential to supply a controlled amount of air to the furnace for effective combustion of fuel and to evacuate hot gases formed in the furnace through the various heat transfer area of the boiler. This can be done by using a chimney or mechanical device such as fans which acts as pump.

Natural draught

When the required flow of air and flue gas through a boiler can be obtained by the stack (chimney) alone, the system is called natural draught. When the gas within the stack is hot, its specific weight will be less than the cool air outside; therefore the unit pressure at the base of stack resulting from weight of the column of hot gas within the stack will be less than the column of extreme cool air. The difference in the pressure will cause a flow of gas through opening in base of stack. Also the

chimney is form of nozzle, so the pressure at top is very small and gases flow from high pressure to low pressure at the top.

Mechanized draught

There are 3 types of mechanized draught systems

1) Forced draught system
2) Induced draught system
3) Balanced draught system

Forced draught: In this system a fan called Forced draught fan is installed at the inlet of the boiler. This fan forces the atmospheric air through the boiler furnace and pushes out the hot gases from the furnace through superheater, reheater, economiser and air heater to stacks.

Induced draught: Here a fan called ID fan is provided at the outlet of boiler, that is, just before the chimney. This fan sucks hot gases from the furnace through the superheaters, economiser, reheater and discharges gas into the chimney. This results in the furnace pressure lower than atmosphere and affects the flow of air from outside to the furnace.

Balanced draught: In this system both FD fan and ID fan are provided. The FD fan is utilized to draw control quantity of air from atmosphere and force the same into furnace. The ID fan sucks the product of combustion from furnace and discharges into chimney. The point where draught is zero is called balancing point.

Ash handling system

The disposal of ash from a large capacity power station is of same importance as ash is produced in large quantities. Ash handling is a major problem.

i) Manual handling: While barrows are used for this. The ash is collected directly through the ash outlet door from the boiler into the container from manually.

ii) Mechanical handling: Mechanical equipment is used for ash disposal, mainly bucket elevator, belt conveyer. Ash generated is 20% in the form of bottom ash and next 80% through flue gases, so called Fly ash and collected in ESP.

iii) Electrostatic precipitator (ESP): From air preheater this flue gases (mixed with ash) goes to ESP. The precipitator has plate banks which are insulated from each other between which the flue gases are made to pass. The dust particles are ionized and attracted by charged electrodes. The electrodes are maintained at 60KV. Hammering is done to the plates so that fly ash comes down and collect at the bottom. The fly ash is dry form is used in cement manufacture.

iv) Flue gas desulfurization (FGD) is a control device used to remove sulfur dioxide (SO_2) from exhaust flue gases using an alkaline reagent to produce a solid copund. In this chemical reaction >90% of the sulfur dioxide (SO_2) from the flue gas can be removed and converts the limestone into calcium sulphite ($CaSO_4$).

- **Generator**

Generator or Alternator is the electrical end of a turbo-generator set. It is generally known as the piece of equipment that converts the mechanical energy of turbine into electricity. The generation of electricity is based on the principle of electromagnetic induction.

Advantages of coal based thermal Power Plant

- They can respond to rapidly changing loads without difficulty
- A portion of the steam generated can be used as a process steam in different industries
- Steam engines and turbines can work under 25 % of overload continuously
- Fuel used is cheaper
- Cheaper in production cost in comparison with that of diesel power stations.

Disadvantages of coal based thermal Power Plant

- Maintenance and operating costs are high
- Long time required for erection and putting into action
- A large quantity of water is required

- Great difficulty experienced in coal handling
- Presence of troubles due to smoke and heat in the plant
- Unavailability of good quality coal
- Maximum of heat energy lost
- Problem of ash removing

31. Why should a steam or moisture separator be installed in the steam line next to a steam turbine?

Answer: All multistage turbines, low-pressure turbines and turbines operating at high pressure with saturated steam should have a moisture separator in order to prevent rapid blade wear from water erosion.

32. What is the safe maximum tripping speed of a turbine operating at 3000 rpm?

Answer: The rule is to trip at 10 percent over speed. Therefore, $3000 \times 1.10 = 3300$ rpm.

33. What is the purpose of a turning gear?

Answer: Heat must be prevented from warping the rotors of large turbines or high temperature turbines of 400°C or more. When the turbine is being shut down, a motor-driven turning gear is engaged to the turbine to rotate the spindle and allow uniform cooling.

34. What is the function of a gland drain?

Answer: The function of a gland drain is to draw off water from sealing-gland cavities created by the condensation of the sealing steam. Drains are led to either the condenser air ejector tube nest or the feed water heaters. Often, gland drains are led to a low pressure stage of the turbine to extract more work from the gland-sealing steam.

35. What are the main causes of turbine vibration?

Answer:

1. Unbalanced parts
2. Poor alignment of parts
3. Loose parts
4. Rubbing parts
5. Lubrication troubles

6. Steam troubles
7. Foundation troubles
8. Cracked or excessively worn parts

36. What are the possible causes of a governor not operating?

Answer:

1. Restriction of throttle valve reflex.
2. Failure of governor control on start-up.

If it is found that after start-up, the speed increases continuously and the governor is not closing the throttle valve, it may be that the governor pump has been installed in the wrong direction.

37. What are two types of clearance in a turbine?

Answer:

1. Radial - the clearance at the tips of the rotor and casing
2. Axial - the fore-and-aft clearance, at the sides of the rotor and the casing.

38. What is an air ejector?

Answer:

An air ejector is a steam siphon that removes non-condensable gases from the condenser.

39. What is the function of a thrust bearing?

Answer: Thrust bearings keep the rotor in its correct axial position

40. What are the causes of Hogging and Sagging of steam turbine rotor?

Answer:

1) Hogging is when the turbine is shut down faster than normal or under trip conditions and the natural cooling of the rotor is not allowed to happen, usually happens when the barring system or turning gear fails to start, the rotor bends in an upward motion in the middle and makes contact with the stator or casing thus allowing rubbing etc. to occur.

How to avoid:-

The only way to overcome this is to have effective barring or turning gear systems to keep the rotor turning as it cools thus not allowing the rotor to hog upwards. If the automatic system of turning gear fails then it is a must to confirm the manual running of turning gear.

2) Sagging of the rotor happens when the rotor is at ambient temperature and barring is not in place so over time the weight of the rotor which is only supported on the rotor bearings allows the rotor to sag in the middle and again the rotor can come into contact with the stator or casing.

If this occurs hand baring of the rotor is the only option 0.5 of a turn say every half hour until the rotor becomes uniform in shape again once in it uniform shape (could take many hours) the barring system can be put into service .

41. What is difference between plant availability and reliability?

Answer: The basic definition of the availability of a power plant is defined as

A = (P-S-F)/P

Where, P = Period of time, hours, usually this is assumed as one year, which amounts to 8760 hours

S = Scheduled outage hours for planned maintenance

F = Forced outage hours or unplanned outage due to repair.

The basic definition of the reliability of a power plant is defined as

R = (P-F)/P

42. What are the performance parameter of a cooling tower?

Answer:

Range: It is the difference between cooling water inlet temperature and cooling water outlet temperature. High CT

Range means that the cooling tower has been able to reduce the water temperature effectively, and is thus performing well.

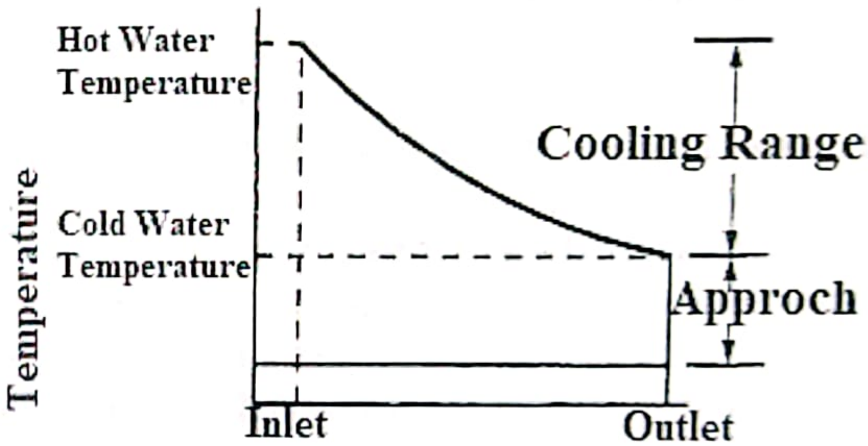
Range = $T_{\text{Hot water in}} - T_{\text{Cold water out}}$

Approach: It is the difference between the cooling tower outlet cold-water temperature and ambient wet bulb temperature. The lower the approach the better the cooling tower performance. Although, both range and approach should be monitored, the `Approach' is a better indicator of cooling tower performance.

Approach= $T_{\text{cold water out}} - T_{\text{wet bulb temperature}}$

Effectiveness: Effectiveness = $\frac{\text{Range}}{\text{Range + Approach}}$

$$=100\times\frac{T_{\text{Hot water in}}-T_{\text{Cold water out}}}{T_{\text{Hot water in}}-T_{\text{wet bulb}}}$$



Water Travel Distance Through Tower

Example: In Haripur Power Ltd. an induced draft cooling tower water inlet temperature is about 40°C and outlet water temperature is 33°C at summer. If wet bulb temperature is 27°C on a specific sunny day, find the range, approach and efficiency of the cooling tower.

Ans.: 7°C; 6°C; 53.84%

43. What is gland-sealing steam?

Answer: Low-pressure steam is led to a sealing gland. The steam seals the gland, which may be a carbon ring or of the labyrinth type, against air at the vacuum end of the shaft.

44. What is meant by critical speed?

Answer: It is the speed at, which the machine vibrates most violently. It is due to many causes, such as imbalance or harmonic vibrations set up by the entire machine. To minimize damage, the turbine should be hurried through the known critical speed as rapidly as possible but to do that be sure the vibration is caused by critical speed and not by some other trouble.

45. How to prevent turbine deposition?

Answer: By upgrading the quality of steam and by ensuring proper quality of the following.

1. Boiler feed water quality.
2. Steam boiler model.
3. Boiler design.
4. Boiler operation.

46. What are the losses in steam turbines?

Answer:

1. Residual Velocity Loss - This is equal to the absolute velocity of the steam at the blade exit.
2. Loss due to Friction - Friction loss occurs in the nozzles, turbine blades and between the steam and rotating discs. This loss is about 10%.
3. Leakage Loss.
4. Loss due to Mechanical Friction - Accounts for the loss due to friction between the shaft and bearing.
5. Radiation Loss - Though this loss is negligible, as turbine casings are insulated, it occurs due to heat leakage from turbine to ambient air which is at a much lower temperature than the turbine.
6. Loss due to Moisture - In the lower stages of the turbine, the steam may become wet as the velocity of water particles is lower than that of steam. So a part of the kinetic energy of steam is lost to drag the water particles along with it.

47. What are three types of condensers? Which is mostly used as steam turbine condenser.

Answer:

1. Surface (shell-and-tube)
2. Jet
3. Barometric.

Among all of the types 'surface' type condensers are mostly used.

48. What does the term 'ramp rat' mean?

Answer: Ramp rate is used in bringing a turbine up to operating temperature and is the degrees Fahrenheit rise per hour that metal surfaces are exposed to when bringing a machine to rated conditions. Manufactures specify ramp rates for their machines in order to avoid thermal stresses. Thermocouples are used in measuring metal temperatures.

49. What is combined-cycle cogeneration?

Answer: A combined cycle using a gas turbine or diesel, usually driving a generator in which the exhaust gases are directed to a waste heat-recovery boiler or heat-recovery steam generator (HRSG). The steam from the HRSG is then directed to a steam turbogenerator for additional electric power production. The use of the exhaust heat from a gas turbine improves the overall thermal efficiency. In cogeneration, electric power is produced, but part of the steam from the HRSG or from extraction from the steam turbine is used for process heat, hence the term cogeneration-the simultaneous production of electric power and process heat steam.

Coal Based Thermal Powerplant Senario of Bangladesh

Coal-Fire Power Matarbari Ultra Super Critical

Company name	Coal Power Generation Company Bangladesh Limited(CPGCBL)
Location	Moheshkhali, Cox's Bazar, Bangladesh.
Capacity	2×600MW
Area	1414.65Acre
Plant Type	Ultra Super Critical
Primary Fuel	Sub-bituminous Coal having GCV of 4200-5200 kcal/kg and low Sulfur content (1.0 wt.% or less)
Fuel Equipment	Around 3.73 million tonne per annum
Environment Safety measures	Low NOx burner and over fire air, seawater FGD and electrostatic precipitator will be facilitated to reduce emissions and pollutions and to meet WHO standard for ambient on qualities.
Chimney Height	275m
Power Evacuation	400KV Double Circuit Line
Estimated Project Cost	USD 4.6Billion Tk. 35,984Crore Local (Bd Government); Tk, 7045 Crore Project Aid: Tk 28939 Crore
Water intake	Necessity of water volume: 25(m^3/sec/unit) × 2 units = 50(m^3/sec)

Boiler Parameters

Parameter	Measures
Type	Radiant reheat, variable pressure operation,

	once-through boiler (outdoor installation)
Quantity	2 units
Main Steam Flow	1760 t/h
Reheat Steam Flow	1490 t/h
Main Steam Pressure	25.4 MPa(g) at superheater outlet
Main Steam Temperature	604°C at superheater outlet
Reheat Steam Temperature	602°C at superheater outlet
Firing System	Pulverized coal firing with low NOx burners and two stage firing and light oil (30% capacity) for unit start up and low load operation
Draft System	Balance Draft

Coal sources

Considering suggested coal specification, availability, cost of coal, cost of transportation and reliability to supply coal, it has been judiciously planned to import coal from Indonesia, Australia and South Africa under long term/short term agreements with coal producers and suppliers. In such case, good quality Sub-bituminous coal can be imported from Indonesia and Bituminous coal can be imported from South Africa and Australia. In this case of multiple sources, GCV of average 4,700 (GCV 4,200 - 5,200 as received basis) kcal/kg to be achieved through blending of different coals of different grades has been considered for planning purposes.

Ash utilization

Various studies have been conducted regarding effective utilization of coal ash produced in large quantities in boilers, and the following uses have proven practical.

- Clinker

- Road bed material
- Fly ash
- Material for cement
- Concrete aggregate
- Road pavement
- Fertilizer

Generator

The main parameters of the generator are as follows:

a) Nominal rating: 600 MW
b) Rated output: 750 MVA
c) Power factor: 0.80 (lag) - 0.95 (leading)
d) Rated Voltage: As per manufacturer's standard (in the range of 18-25 kV)
e) Speed: 3000 rpm
f) Short Circuit ratio: Not less than 0.50

The annual Coal requirement of 2×600MW units Shall be about 3.7million tons based on fill of 4700kal/kg, plant capacity factor of 80% and gross generation efficiency of 41.29% (unit heat rate of 2082.5kcal/kWh)

[All information are collected from respective websites]

Rampal

The proposed power plant shall be joint venture of Bangladesh Power Development Board (BPDB) and NTPC Ltd., India. In this context, BPDB and NTPC Ltd., India has signed the Joint Venture Agreement at Dhaka on 29 January 2012. Name of company shall be "Bangladesh-India Friendship Power Company". Bangladesh and India (50:50) would invest 30 percent of its total cost for the coal-fired project while the remaining 70 percent would be obtained through loans from external sources. The proposed project is to be constructed in Rampal that covers Sapmari Katakhali and Kaigar Daskati Mauza of Rajnagar Union under Rampal Upazila in the district of Bagerhat.

Coal sources:

Considering suggested coal specification, availability, cost of coal, cost of transportation and reliability to supply coal, judiciously it has been planned to import coal from Indonesia, Australia and South Africa under long term/short term agreement with coal producers and suppliers. In such case, good quality, Sub-bituminous coal might be imported from Indonesia (GCV 5500–5800 kcal/kg AR basis) and Bituminous (GCV 5800 – 6300 kcal/kg AR basis) coal might be imported from South Africa and Australia.

In this case of multiple sources, GCV of average 6000 Kcal/kg to be achieved blending of different coals of different grades has been considered for planning purpose. BPDB would engage third parties to supply coal and transport coal up to the project site under Coal Supply Agreement and Coal Transportation Agreement with the outsourced agencies.

Proposed Project At a Glance

Component	**Design condition**
Plant type	Supercritical Pulverized Coal
Carbon capture	No
Net power output	1320 MW
Primary fuel (type)	Bituminous or Sub-bituminous coal
Coal requirement	12,920 MT/Day (for 100% Plant factor)
Ash production	15%
Flue gas flow	4.47×106 Nm3/hr
Temperature of flue gas at stack	1250 temperature
Emission SOx max	819 g/s from each unit
Emission NOx max	490 g/s from each unit
Particulate matter	100 μg/Nm3 from each unit
Stack height	275 m
Water intake (Make up	9,150 m3/hr (<0.04% of the dry

water, 2.5417 m3/s)	season discharge of the Passur)
Water discharge (within ECR 1997 standard)	5,150 m^3/hr
Water consumed	4,000 m^3/hr
Thermal Plume/Heated Water Discharge	No discharge of heated water

Source: Feasibility Study Report

Basic plant information of the proposed coal based thermal power plant (feasibility Study Report).

Component	**Design condition**
Plant type	Supercritical PC
Carbon capture	Nil
Net power output	1320 MW
Primary fuel (type)	Bituminous and Sub-bituminous Coal having GCV of 6000Kcal/Kg (after mixing) and low Sulfur content (0.6%)
Coal flow	12,920 T/Day (at 100% plant load factor)
Annual coal requirement	4.72 MT/year (considering 100% load factor)
Ash production	15%
Temperature of flue gas at stack	125^{O}C
Flue Gas Flow	4.47×10^6 Nm^3/hr
Flue Gas Desulfurization (FGD)	To maintain concentration of Sulfur in ambient air below the MoEF standard (80 μg/Nm^3 and 30μg/Nm^3 for Sundarbans world Heritage)
Maximum emission of SOx	819g/s
Maximum emission of NOx	490g/s (less than 750 μg/Nm^3)

Particulate matter	100 µg/Nm^3
Stack height	275 m
Water Intake (Make up water)	9,150 m^3/hr (e.g. 2.5 m^3/s) (less than 0.5% of lowest flow condition in Passur River)
Water discharge after treatment	5,150 m^3/hr
Water consumed	4,000 m^3/hr

Boiler parameter

Sl No	Parameter	Measures
1	Steam flow at main super-heater outlet	2120 T/hr
2	Pressure at super-heater outlet	256 kg/cm^2
3	Temperature at super-heater outlet	568^0C
4	Steam flow to re-heater	1708.2 T/hr
5	Steam temperature at re-heater outlet	596^0C
6	Feed water temperature at economizer inlet	293.7^0C

The main parameters of Generator would be as follows:

a) Nominal rating 660 MW
b) Rated output 777MVA
c) Power factor 0.85 (lag)-0.95 (leading)
d) Rated Voltage As per manufacturer's Standard (in the range of 21-24 kv)
e) Speed 3000rpm
f) Short Circuit ration Not less than 0.48

Salient Features of Payra 1320 MW Thermal Power Plant Project (1st Phase)

EPC Contractor	Consortium of NEPC & CECC, China
EPC Contract Price	1,720,117,137.00 USD 3,957,128,368.00 BDT
Total Project Cost	2.48 Billion USD
Project Financier	CEXIM Bank
Progress of EPC Work	Physical_Progress:93.26% (1st Phase) Financial_Progress:71.35% (1st Phase)
Plant capacity	1320 MW (2 × 660 MW)
Boiler Technology	Ultra Supercritical (26.25MPa/600/610°C)
Turbine Heat Rate	7522 KJ/KWh
Cooling Water System	Closed Circulation of Water Using Cooling Tower
Power Evacuation	400 KV GIS Substation 400 KV Transmission Line (Payra Power Plant – Gopalganj – Dhaka)
Primary Fuel	Sub – Bituminous / Bituminous Coal
Coal Sourcing	P.T. Bayan Resources Tbk, Indonesia
Coal Transportation	Oldendorff, Germany
Expected COD	First Unit: December, 2019 Second Unit: June, 2020

Source: https://www.bcpcl.org.bd/power-plant

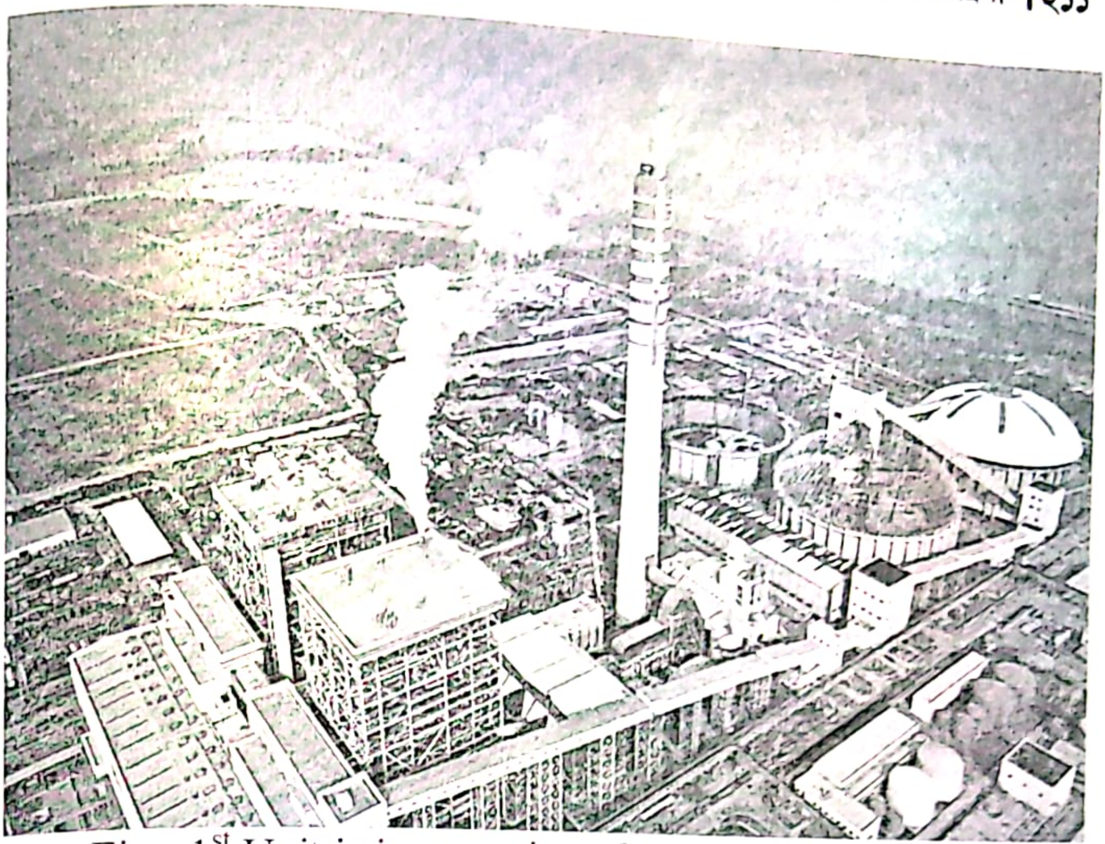
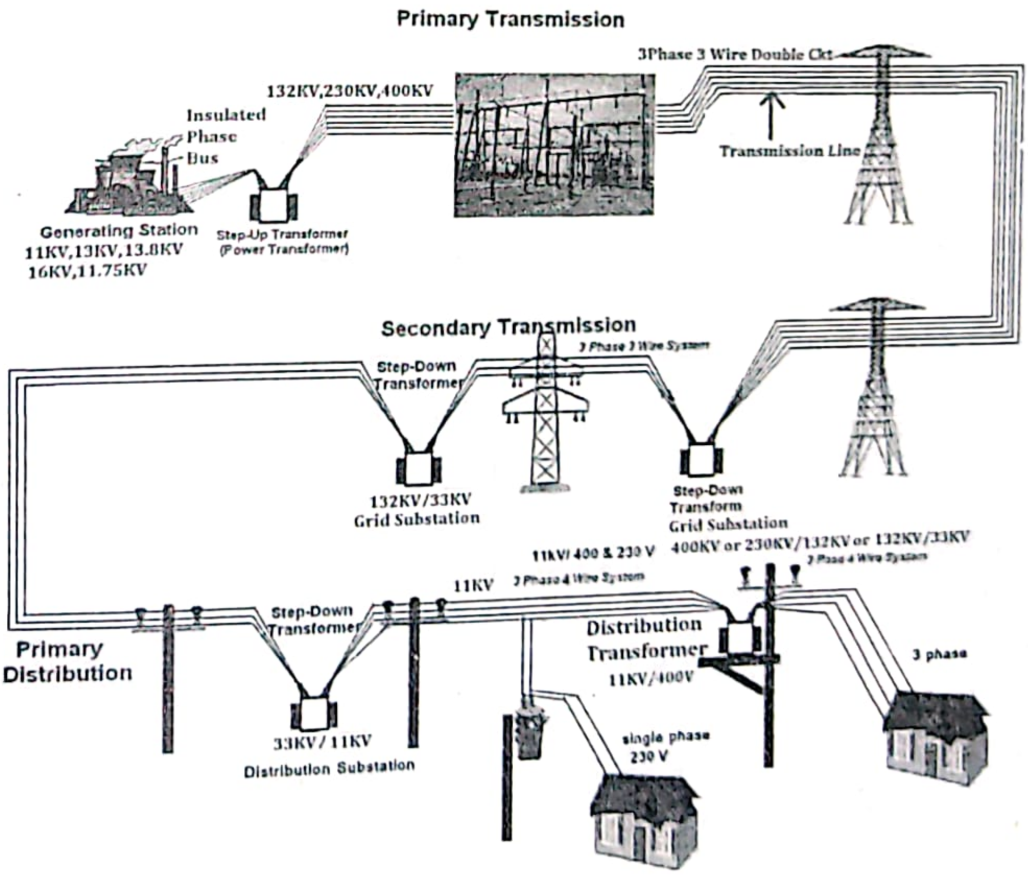


Fig.: 1st Unit is in operation of Payra coal power plant
[Photo source: The Daily Star, January 14, 2020]

Power Distribution System of Bangladesh



HFO Power Plant

এই লেখাটি অনেকদিন আগে আমি ফেসবুকে প্রকাশ করেছিলাম। তারপর লেখাটি বেশকিছু ফেসবুক পেজে এবং ব্লগে প্রকাশিত হয়েছিল।

HFO Power Plant

দেশে কিছু কুইক রেন্টাল পাওয়ার প্ল্যান্ট তৈরি হতে শুরু করেছিল কয়েক বছর আগে। তখন দ্রুততার সাথে প্ল্যান্টগুলো সার্ভিসে আসাটায় ছিল মূল বিষয়। ওই সময় ইঞ্জিন বেজ পাওয়ার প্ল্যান্টের প্রতি মনোনিবেশ বেড়ে গিয়েছিল এবং এইসব ইঞ্জিন বেজ প্ল্যান্টের ফুয়েল হিসেবে ব্যবহৃত হয় Heavy Fuel Oil বা HFO. এখনো এই ফুয়েল ব্যবহার করে পাওয়ার প্ল্যান্ট গড়ে উঠছে। তবে অদূর ভবিষ্যতে বৃহৎ পাওয়ার প্ল্যান্টগুলো চালু হলে এর ব্যবহার কমে আসবে।

একটা HFO ভিত্তিক পাওয়ার প্ল্যান্টে কি কি থাকে?

ইঞ্জিনঃ এটি মূলত internal combustion Engine যা সম্পূর্ণ Diesel Engine এর কার্যকরীতা বিশিষ্ট। শুধুমাত্র ফুয়েল হিসাবে Diesel এর জায়গায় HFO ব্যবহার করা হয়। আবার এটাকে সম্পূর্ণ Marine Engine বলা চলে। বাংলাদেশে Wartsila, MAN এইসব কোম্পানীর ইঞ্জিন ব্যাপকভাবে ব্যবহৃত হচ্ছে। তাছাড়াও CAT, STX এর ইঞ্জিনও ব্যবহৃত হচ্ছে।

ফুয়েলঃ HFO ফুয়েল এক ধরনের Complex group of Hydrocarbon products যা মূলত 'Refinery Residual' (residues of crude oil refining process) এবং আলকাতরা সদৃশ অয়েল। এর কম্বাশনে পরিবেশে কালো কার্বন ধোঁয়া ছড়িয়ে পড়ে এবং কম্বাশন প্রোডাক্ট হিসাবে particulate matter, NOx, SOx এসব বহন করে। তবে চিমনির আধুনিক ডিজাইন এইসব ক্ষতিকর ধোঁয়া নির্গমনে বাধা প্রদান করে।

HFO Main & secondary storage tank: এখানে সরাসরি জাহাজ/লরি/ট্রেন থেকে টান্সফার পাম্পের মাধ্যমে HFO unload করে store করা হয় এবং এর ভিতরে নির্দিষ্ট তাপমাত্রা ($50^{o}C$ এর মত) maintain করার জন্য Steam supply দেওয়া হয়।

Oil Purifier: এখানে দুই ধরনের Oil Purifier আছে। বলা হয়ে থাকে HFO সবচেয়ে dirty ফুয়েলগুলোর একটি। তাই এক ধরনের Purifier ব্যবহার হয় HFO purification এর জন্য। আরো এক ধরনের Purifier ব্যবহার করা হয় lube Oil purification এর জন্য।

HFO Filter: অনেক সময় HFO Purifier এরপর duplex HFO Filter ব্যবহার করা হয়।

Service Tank/Day tank: ইঞ্জিনে মেইন ফিড দেওয়ার জন্য Tank/Day tank-এ ফুয়েল সরবরাহ করা হয়। এখানে তাপমাত্রা আরো বেশি থাকে (70°C-90°C এর মত)।

HFO Booster Module: এইখানে HFO কে heating এর মাধ্যমে এর density adjust করা হয় এবং viscosity module এর মাধ্যমে viscosity adjust করা হয় ।

Booster Module to Engine: Booster Module থেকে filtered HFO এরপর ইঞ্জিনে যায়। আর এইপথ (Booster Module to Engine) অতিক্রম করতে সাহায্য করে high pressure fuel pump and fuel injection valve/fuel injector.

Fuel Pump: একটি plunger type high-pressure fuel pump থাকে যেখানে মূলত একটি cylinder এর ভিতর একটি plunger reciprocating motion এ চলে।

Fuel Injector: Combustion chamber এ fuel inject করতে Fuel injector ব্যবহার করা হয়। এটি fuel এর পরিমাণ ঠিক রেখে fuel কে atomize এবং vaporize করে compressed air এর সাথে mix করে। Fuel pump high pressure-এ fuel injector-এ fuel delivery দিয়ে থাকে।

বি.দ্র. অনেক সময় দেখা যায় Booster Module থেকে Fuel Pump এর আগে একটা Fuel Accumulator থাকে, যা ইঞ্জিনে emergency backup হিসাবে ব্যবহার হয়।

Engine: Engine মূলত মাল্টি সিলিন্ডার ডিজেল ইঞ্জিন। সুতরাং এখানে আর বিস্তর আলোচনা করা হলো না।

Lubricating Oil System: ইঞ্জিনে প্রচুর পরিমাণে Lubricating Oil লাগে। নির্দিষ্ট মেয়াদ শেষে Lubricating Oil চেঞ্জ করতে হয়। Engine lubrication system-এ সাধারণত দুই ধরনের pump থাকে। একটা pre-lubrication pump যা ইঞ্জিন চালু হওয়ার আগে চালাতে হয় এবং এটি motor driven. পরে main lubrication pump চালু হয় যা engine driven. Lube oil engine lubrication শেষ করে Engine sump এ জমা হয় এবং engine sump থেকে সেটি lube oil cooler-এ যায়। oil cooler থেকে বের হয়ে এটি oil separator হয়ে আবার সিস্টেমে প্রবেশ করে।

Engine Cooling System: Cooling System-এ সাধারণত দুই ধরনের cooling water ব্যবহৃত হয়। একটি Low Temperature Cooling water (LT) এবং অপরটি High Temperature Cooling water (HT). Engine এর Thermal Stress কে বিবেচনায় রেখে এই দুই ধরণের পৃথক তাপমাত্রার

Cooling water ব্যবহার করা হয়। কারণ Heavy Hot body কে খুব বেশি ঠান্ডা medium দ্বারা Cool করলে ঐ body এর deformation হতে পারে।

Low Temperature Cooling water (LT): LT water সাধারণত charge air এর temperature control করতে ব্যবহার করা হয়। এছাড়া বিভিন্ন Heat Exchanger যেমনঃ Lube oil cooler -এ ব্যবহৃত হয়।

High Temperature Cooling water (HT): HT water-কে বলা হয় Jacket water. Cylinder liner, cylinder head ইঞ্জিনের ইত্যাদি অংশের তাপমাত্রা কমিয়ে আনতে HT water ব্যবহার করা হয়।

Cooling Tower বা Radiator: এই cooling water যখন সিস্টেমের তাপমাত্রা কমিয়ে বের হয়ে আসে তখন এর নিজের তাপমাত্রা বেড়ে যায়। তাই এই cooling water এর তাপমাত্রা হ্রাস করতে Cooling Tower বা Radiator ব্যবহার করা হয়।

Turbo Charger: ইঞ্জিনের combustion chamber-এ extra compressed air সরবরাহ করে ইঞ্জিনের efficiency এবং power output বৃদ্ধি করতে Turbo Charger ব্যবহার করা হয়। এটি turbine-driven এক ধরনের forced induction device.

Boiler: HFO plant-এ HFO Storage tank এবং Booster Module-এর তাপমাত্রা ঠিক রাখতে এর Heat exchanging medium হিসাবে steam ব্যবহৃত হয়। এই steam- তৈরির জন্য Boiler বা Steam Generator লাগে। এখানে Boiler-এর Heating medium/ Fuel হিসাবে exhaust gas ব্যবহার করা হয়। যেহেতু exhaust gas এক ধরনের waste gas তাই এই গ্যাসকে কাজে লাগিয়ে যখন Steam Generate করা হয় তখন সেই Boiler-কে Waste Heat Recovery Boiler (WHRB) বলে। তবে প্রাথমিক অবস্থায় যখন ইঞ্জিন চালু থাকে না তখন Heating এর জন্য যে steam লাগে তার জন্য Oil Fired Boiler ব্যবহার করা হয়।

Control Room: এখানে প্ল্যান্টের যাবতীয় সিস্টেমের কন্ট্রোল করা হয়। সারা বিশ্বের পাওয়ার প্ল্যান্টে এখন distributed control system (DCS) ব্যবহার করা হয়। Control Room থেকে প্রতিটা সিস্টেম চালু করা, বন্ধ করা কন্ট্রোল করা, মনিটরিং করা সবই করা হয়। এছাড়াও প্রতিটি পাওয়ার প্ল্যান্টে MCC Room, Battery Room, Ware House/ Store, Workshop, Water Treatment Plant (WTP), Effluent Treatment Plant (ETP)/ Waste Water Treatment Plant (WWTP), Switch Yard এসব থাকে।

Water Treatment System

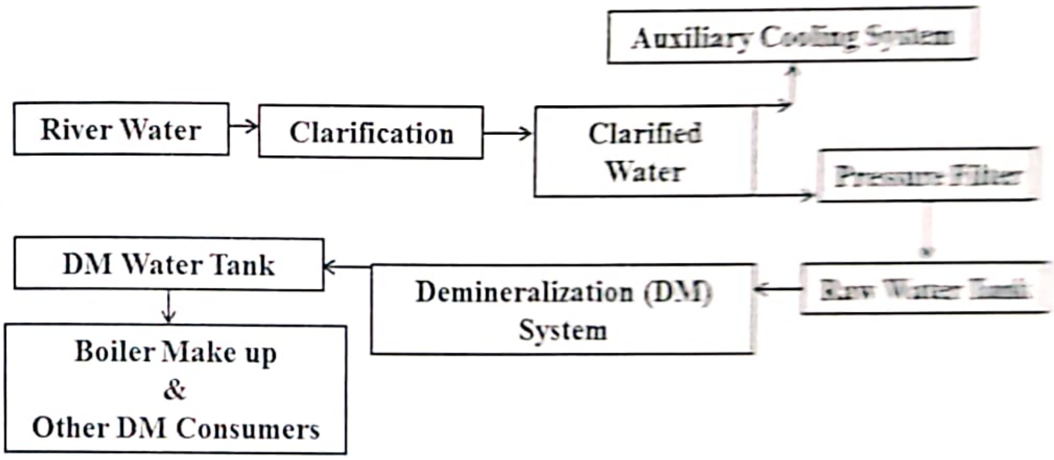
যেকোন ধরনের Power Plant, Food Industry, Phermaceutical industry, Garments বা অন্যান্য Process Industry- গুলোতে Water Treatment Plant খুবই গুরুত্বপূর্ণ। সকল ধরনের Power Plant -এর জন্য Water Treatment System মোটামুটি একই রকম। তবে Sea Water-এর জন্য একটু ব্যতিক্রম আছে।

Power Plant Water Treatment System -এর মূল কারণ হলো বয়লারে Demineralized Water supply দেওয়া এবং Cooling Tower-এ filtered water supply দেওয়া। এছাড়াও প্রয়োজন হয় Service water, Distillate water.

Why water treatment is Necessary:

1. Untreated water leads to scale formation, sludge formation, metal corrosion etc.
2. To protect pipelines, boiler system, turbine blade as well as condenser tubes otherwise it causes deposition and corrosion.
3. Finally it is a measure of safety, economical retention in value of the total power generation system or any other industries.

Simple Flow Diagram of River water Treatment System



So, the river water first goes to the 'clarifier' for clarification. Clarifier comprises with coagulation, flocculation and settling. The clarified water is passed through the pressure filter and stored into a raw water tank. Sometimes a system named 'aeration' is introduced before clarifier in which air allows to ingress into water for the purpose of:

- Making active sludge by aliving the aerobic bacteria
- Making the Feric ions soluble

Coagulation: The process of making big flocs by accumulating the suspended solids of water, which are tiny or not visible to the naked eye. Coagulant chemicals with charges opposite those of the suspended solids are added to the water to neutralize the negative charges on non-settlable solids (such as clay and color-producing organic substances).

Flocculation: Flocculation, a gentle mixing stage, increases the particle size from submicroscopic microfloc to visible suspended particles. Microfloc particles collide, causing them to bond to produce larger, visible flocs called pinflocs. Floc size continues to build with additional collisions and interaction with added inorganic polymers (coagulant) or organic polymers. Macroflocs are formed and high molecular weight polymers, called coagulant aids, may be added to help bridge, bind, and strengthen the floc, add weight, and increase settling rate.

There are two types of plant for preparing boiler feed water preparation.

1. Demineralization plant (DM plant)
2. Reverse Osmosis plant (RO plant)

Demineralization plant (DM plant): Demineralization plant employs a chemical method to separate out the dissolved salt ($CaCO_3$, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$, NaCl, KCl, $NaNO_3$, $CaCl_2$, Na_2SO_4) in raw water. But reverse osmosis plant employs a simple physical method to separate the dissolved salts.

The function of demineralization plant is to remove dissolved salt by ion exchange method (chemical method) and there by producing pure feed water for boiler.

Cation Exchange Resin:

$NaCl+RSO_3H=RSO_3^-Na^++HCl$

Thus H_2SO_4, H_2CO_3 are also produced.

We have removed Na^+ but the water has become acidic.

Degasifier:

The function of degasifier tower is to remove carbonate ions by forming carbon-di-oxide. In degasifier tower stream of water is poured from top and air is blown from bottom to top. In the pressure of air the carbonic acid (H_2CO_3) present in the water dissociates into H_2O and CO_2.

$H_2CO_3=H_2O+CO_2$

This CO_2 is free to mix with air.

Benefits of using degasifier are:

- It removes the carbonic acid and other gases mixed with water by simple physical method and thereby reduce the chances of corrosion.
- It saves the resins which are very costly chemicals and thereby improves the economy of boiler feed water treatment process.

The H_2CO_3 free water is now collected in degasifier sump and then pumped to anion exchange resin inlet.

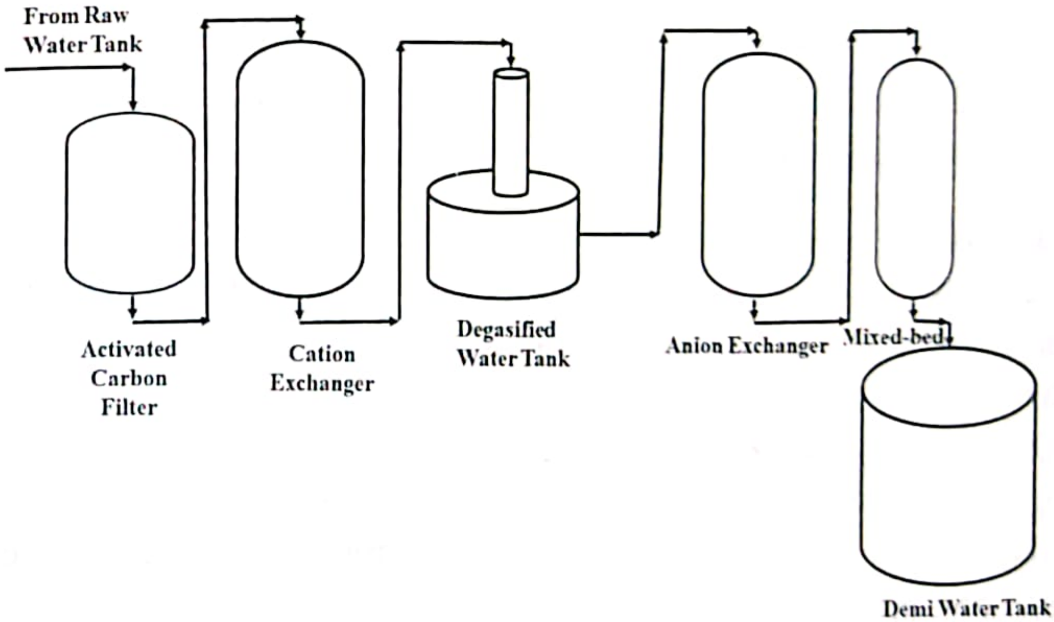


Fig.: Process flow diagram of a typical demineralization system

Anion Exchange Resin:

$HCl+R_4NOH= R_4NCl+H_2O$

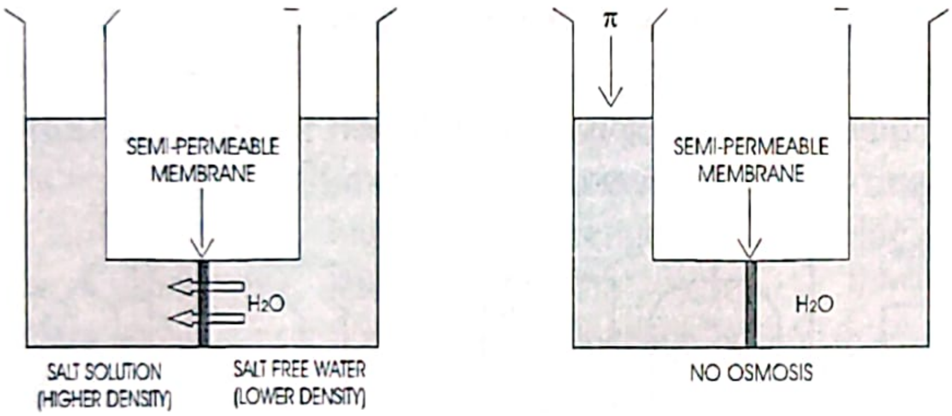
This way we have eliminated Cl^- and thus acidity of the water. Similar reaction for H_2SO_4 also.

Mixed Bed Resins:

These mixed bed resins are used in Demineralization plant of boiler feed water treatment, to remove the ions (especially Na^+ and SO_3^{2-}) which may further present in the water after foregoing process of purification

Reverse Osmosis Plant (RO Plant)

Like demineralization plant there is another stage of water treatment which is known as reverse osmosis plant. RO plant uses the process known as reverse osmosis to produce salt-free water. The theoretical aspect is described below:-



Osmosis is a process in which only the solvent molecules pass through a semi-permeable membrane from higher solvent density to lower solvent density (i.e. from solution of lower density to the solution of higher density).

Osmotic pressure:- It is the minimum pressure that should be applied on the higher density solution so that no osmosis takes place through the semi-permeable membrane is called the osmotic pressure (π).

$\pi = iCRT$

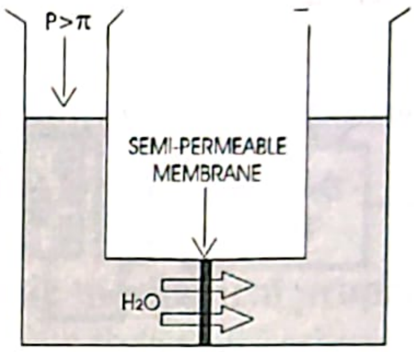
Where,

C is concentration of solution,

R is universal gas constant,

T is temperature in Kelvin scale,

i is van't Hoff's factor, different for different solutions. i = 1 for infinitely dilute solution. Hence osmotic Pressure is a function of temperature.



REVERSE OSMOSIS

Reverse Osmosis:

On the higher density solution (lower density solvent) if a pressure (P), greater than osmotic pressure (π) is applied then the solvent molecules pass through the semi-permeable membrane from higher density solution to lower density solution. This phenomenon is called reverse osmosis. This one important stage for boiler feed water treatment process.

Reverse Osmosis Plant:

In RO plant using reverse osmosis phenomenon salt-free water is taken out from raw water after the sand filtration. Purity of the salt-free water depends on effectiveness of the permeable membrane.

The layout of a typical Reverse Osmosis Plant is given below-

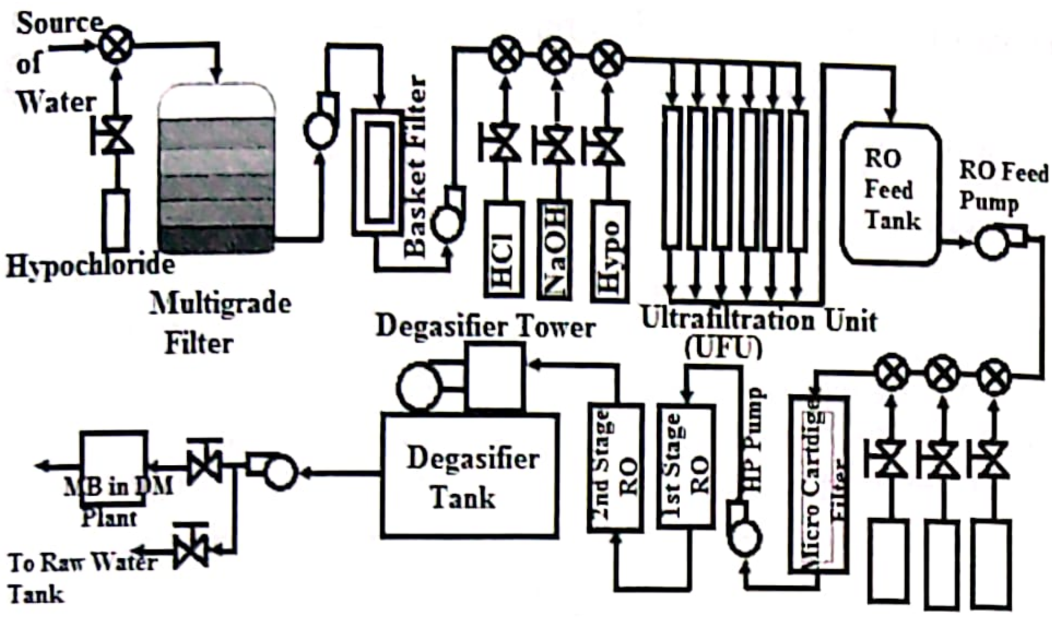
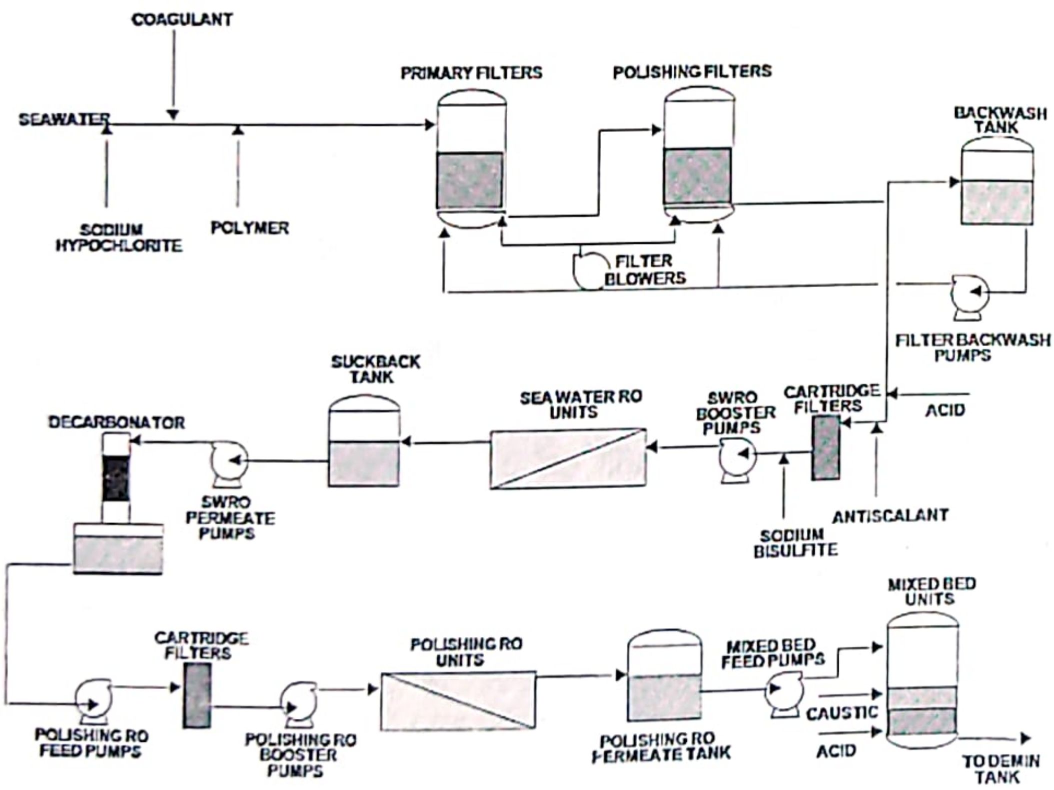


Fig.: A Process Flow Diagram of a RO System

Process Flow Diagram of Sea Water Treatment System



অধ্যায় ৮

Metallurgy and Machine Tool

1. What are the basic mechanical properties of metal?

Answer: These include those characteristics of material that describe its behavior (response) under the action of external forces (loads). It can be determined by conducting experimental tests on the material specimen. Most common properties are strength, Hardness, Toughness, Brittleness, Ductility, Malleability, Elasticity, Plasticity, Rigidity, Resilience, Fatigue and Creep.

a) Strength: It is the ability of a material to resist deformation under the action of tensile, compressive or shear force. The strength of a component is usually based on the maximum load that can be borne before failure is apparent. The most common measure of strength is the yield strength.

b) Hardness: It is the ability of a material to offer resistance to penetration or indentation. It is also the ability to resist wear, abrasion, scratch or cutting.

c) Toughness: It describes a material's resistance to fracture under impact loading. It is often expressed in terms of the amount of energy a material can absorb before fracture. Toughness is not a single property but rather a combination of strength and ductility.

d) Brittleness: It is that property by virtue of which a material breaks easily under action of shock loads without appreciable amount. It indicates the lack of ductility. For example glass, ceramics and cast iron are brittle materials.

e) Ductility: It is a measure of the amount of deformation of a material can withstand before breaking. It is also the ability of a material by which it can be drawn into wires.

f) Malleability: It is the ability of a material by which it can be rolled into sheets. Malleability is the ability of a material to exhibit large deformation subjected to compressive force whereas ductility is the ability of a material to deform upon the application of tensile force. Aluminum, Copper and gold have good malleability.

g) Elasticity: It is the property of a material to regain its original shape after the removal of load. When a material is subjected to an external load of such magnitude that deformation continues only with increase in load, and on removing the load it regains its original shape, then the material is said to have elasticity.

h) Plasticity: It is the property of a material by virtue of which it undergoes permanent deformation. When a material is subjected to an external load of such magnitude that deformation continues with no apparent further increase in load, the material is said to have become plastic. In this reason the material experiences permanent deformation and does not return to its original shape when the load is removed.

i) Rigidity: It is also known as stiffness. It is the property of a material by virtue of which the material resists elastic or plastic deformation under applied loads.

j) Machinability: It refers to the ease with which a material can be removed during various machining operations. It describes the property of a material when it is cut. Materials with good machinability require less power to cut, resulting in good surface finish and longer cutting tool life.

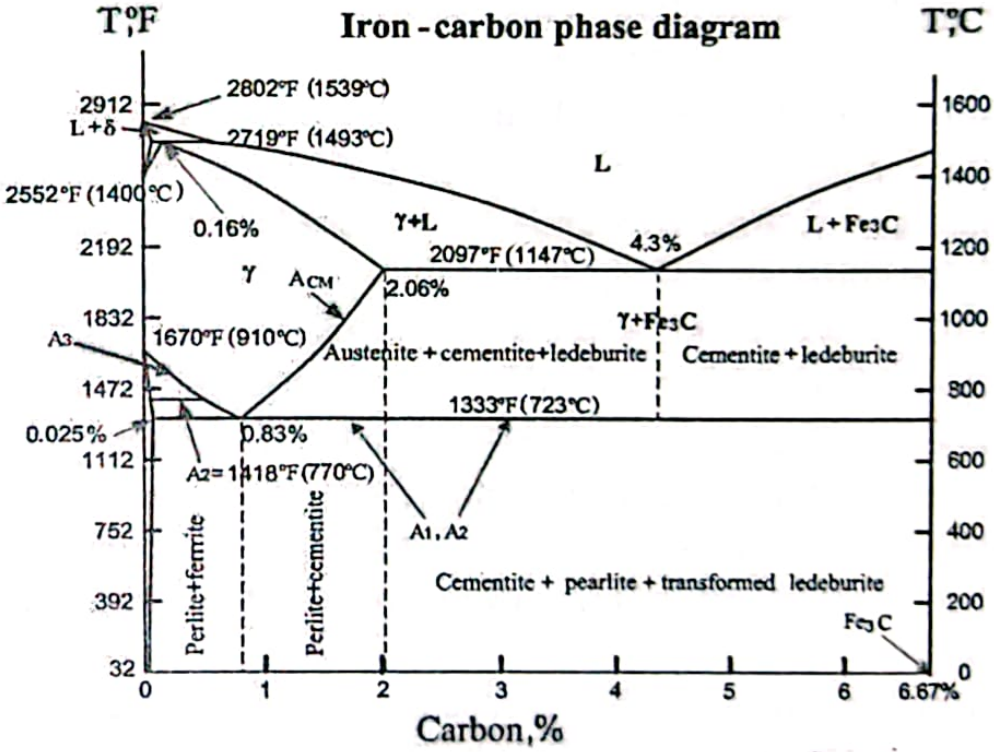
k) Hardenability: It indicates the degree of hardness that a material can acquire through a hardening process. It is the capability of a material to get hardened by heat treatment. It determines the depth and distribution of hardness induced by quenching.

l) Resilience: It is the property of a material to absorb energy when it is deformed elastically and then, upon unloading, to have this energy recovered. In other words, it is the maximum energy per volume that can be elastically stored.

m) Fatigue: It is the strength of the materials when subjected to cyclic or rapid fluctuating load conditions. Owing to fatigue a material fails at a stress level much below that under static loads. The maximum stress to which the material can be subjected without fatigue failure is known as the endurance limit.

n) Creep: It is the progressive deformation of a material under a constant static load maintained for a long period of time. It is a slow, temperature-aided, time dependent deformation. It occurs in three stages known as primary, secondary and tertiary stage.

2. Draw an iron-carbon phase diagram.



3. What is Heat treatment process and why it is done?

Answer: The process of heat treatment is carried out first by heating the metal and then cooling it in the caustic soda solution, brine, water, oil or air. The purpose of heat treatment

is to soften the metal, to change the grain size, to modify the structure of the material and to relieve the stresses set up in the material after hot or cold working.

4. What is Annealing?

Answer: It is one of the most important process of heat treatment of steel. Following are four types of annealing:

(a) **Full annealing:** The purpose of full annealing is to soften the metal, to refine the grain structure, to relieve the stresses and to remove trapped gases in the metal. The process consists of heating the steel 30^0C-50^0C above the upper critical temperature for hypo-eutectoid steel and by the same temperature above the lower critical temperature for hyper-eutectoid steels. It is held at this temperature for sometimes and then cooled slowly in the furnace.

(b)**Process annealing:** It is also known as low temperature annealing or sub-critical annealing. This process is used for relieving the internal stresses previously set up in the metal and for increasing the machinability of the steel. In this process, steel is heated to a temperature below or close to the lower critical temperature (generally 550°C-650°C), held at this temperature for sometimes and then cooled slowly.

(c) **Spheroidise annealing:** It is usually applied to high carbon tool steels which are difficult to machine. The operation consists of heating the steel to a temperature slightly above the lower critical temperature (730°C-770°C). It is held at this temperature for sometimes and then cooled slowly to temperature at 600°C. The spheroidising improves the machinability of steels, but lowers the hardness and tensile strength.

(d)**Diffusion annealing:** This process is mainly used for ingots and large castings. The process consists of heating the steel to a high temperature (1100°C-1200°C). It is held at this temperature for 8-20 hours and then cooled to 800°C-850°C inside the furnace for a period of about 6 to 8 hours. It is further cooled in the air to room temperature.

5. Why Normalizing is done?

Answer: The normalizing is done for the following purposes:

(a) To refine the grain structure of the steel to improve machinability, tensile strength and structure of weld.

(b) To remove strains caused by cold working processes.

(c) To remove dislocations caused in the internal structure of the steel due to hot working.

(d) To remove certain mechanical and electrical properties.

The process of normalizing consists of heating the steel 30^0C-50^0C above its upper critical temperature for hypo-eutectoid steels or Acm line for hyper-eutectoid steels. It is held at this temperature for about fifteen minutes and then allowed to cool down in still air. The process of normalizing is frequently applied to castings and forgings etc.

6. Why Hardening is done?

Answer: The main objectives of hardening are-

(a) To increase the hardness of the metal so that it can resist wear.

(b) To enable it to cut other metals, i.e. to make it suitable for cutting tools.

The process of hardening consists of heating the metal to a temperature of 30^0C to 50^0C above the upper critical point for hypo-eutectoid steels and by the same temperature above the lower critical temperature for hyper-eutectoid steels. It is held at this temperature for a considerable time and then quenched in a suitable cooling medium.

7. What is the purposes of Austempering, Martempering and tempering?

Answer:

Austempering: The austempering is misnomer because it is not a tempering process, but a hardening process. It is also known as isothermal quenching. In this process, the steel is heated above the upper critical temperature, at about 875^0C where the structure consists entirely of austenite. It is then

suddenly cooled by quenching it in a salt bath or lead bath maintained at a temperature of about 250^0C to 525^0C.

Martempering: This process is also known as stepped quenching or interrupted quenching. It consists of heating steel above the upper critical point and then quenching it in a salt bath kept at a suitable temperature.

Tempering: The tempering (also known as drawing) is done for the following reasons:

(a) To reduce brittleness of the hardened steel and thus to increase ductility.

(b) To remove internal stresses caused by rapid cooling of steel.

(c) To make steel tough to resist shock and fatigue.

The tempering process consists of reheating the hardened steel to some temperature below the lower critical temperature, followed by any desired rate of cooling.

7. **Surface hardening or Case hardening:** In many engineering applications, it is desirable that steel being used should have a hardened surface to resist wear and tear. At the same time, it should have soft and tough interior or core so that it is able to absorb any shocks etc. This type of treatment is applied to gears, ball bearings, railway wheels etc. The various surface or case hardening processes are as follows:

(a) Carburizing; (b) Cyaniding; (c) Nitriding; (d) Induction hardening; and (e) Flame hardening.

8. What is welding?

Answer: The welding is a process of joining two similar or dissimilar metals by fusion, with or without the application of pressure and with or without the use of filler metal.

9. Classify welding?

Answer: The welding is broadly divided into the following two groups:

(1) Forge or pressure welding (under pressure without additional filler metal).

(2)Fusion or non-pressure welding (with additional filler metal).

10. Describe the process of Electric resistance welding.

Answer: It is a type of pressure welding. It is used for joining pieces of sheet metal or wire. The welding heat is obtained at the location of the desired weld by the electrical resistance through the metal pieces to a relatively short duration, low voltage (from 6 to 10 volts only) high amperage (varying from 60 to 4000 amperes) electric current. The amount of current can be regulated by changing the turns of the transformer. When the area to be welded is sufficiently heated, the pressure varying from 25 to 55 MPa is applied to the joining area by suitable electrodes until the weld is solid. The various types of electric resistance welding are as follows:

1. **Spot welding, 2. Roll spot and seam welding,**
3. Projection welding, 4. Butt welding.

11. Describe the process of arc welding.

Answer: The arc welding is a fusion welding process in which the welding heat is obtained from an electric arc struck between the work and an electrode. The temperature of heat produced by the electric arc is of the order of 6000°C to 7000°C. Both the direct current and alternating current may be used for arc welding, but the direct current is preferred for most purposes. When the work is connected to the positive terminal of a D.C. welding machine and the negative terminal to an electrode holder, the welding set up is said to have straight polarity. On the other hand, when work is connected to negative and electrode to a positive terminal, then the welding set up is said to have reversed polarity. The straight polarity is preferable for some welds while for other welds reversed polarity should be used. Following are the two types of arc welding depending upon the type of electrode:

(a) **Un-shielded arc welding:** When a large electrode or filler rod is used for welding, it is said to be un-shielded arc welding.

(b)**Shielded arc welding:** When the welding rods coated with fluxing material are used, then it is called shielded arc welding.

Metallic inert-gas (MIG) arc welding: In MIG welding, the electrode is consumable. The filler metal is deposited by the arc which is completely surrounded by an inert gas.

Tungsten inert-gas (TIG) arc welding: In TIG welding, the heat is produced from an arc between the non-consumable tungsten electrode and the work piece. The welding zone is shielded by an atmosphere of inert gas supplied from a suitable source. The direct current with straight polarity is used for welding copper alloys and stainless steel, whereas the reversed polarity is used for magnesium. The alternating current is more versatile in welding for steel, cast iron, aluminium and magnesium.

12. What are the types of Welding Electrodes?

Answer: Basically, depending upon the process there are two types of welding electrodes,

i) Consumable Electrodes: Filler metal can be coated or non-coated.

ii) Non-Consumable Electrodes: Made of tungsten or carbon which doesn't melt in the process of welding.

13. State Different types of machining operation.

Answer:

Drilling: It is an operation of producing holes in metals or other materials.

Turning: Turning is the removal of metal from the outer diameter of a rotating cylindrical workpiece. Turning is used to reduce the diameter of the workpiece, usually to a specified dimension, and to produce a smooth finish on the metal.

Milling: Milling consists of machining metal by bringing it into contact with a rotating cutting tool having a number of cutting edges.

Grinding: Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool.

Shaping: The machining of plane surfaces in a shaper.

14. What is a Gear?

Answer: A gear is a rotating machine element having cut teeth which mesh with another toothed part, usually having teeth of similar size and shape, in order to transmit power. Gears are toothed members which transmit power / motion between two shafts by meshing without any slip.

15. Difference between Pinion & Gear.

Answer: The smaller of two mating gears is called the 'pinion' and the larger is called the gear.

16. Describe the nomenclature of a gear.

This illustrates the terminology of a spur gear as the spur gear is very simple.

Pitch circle: The theoretical circle upon which all gear calculations are based and its diameter is called the 'pitch diameter'.

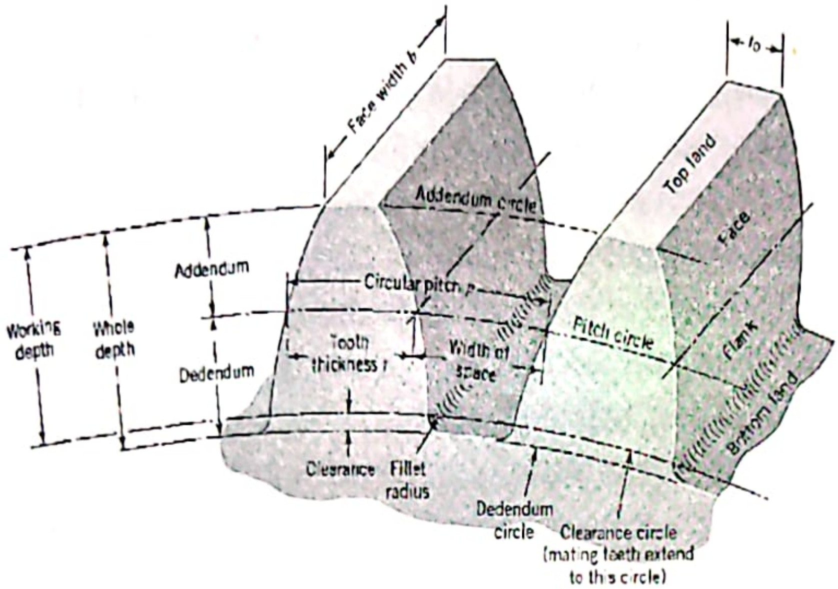
Addendum 'b': The radial distance from the pitch circle to the top surface of the teeth.

Dedendum 'c': The radial distance from the pitch circle to the bottom surface of the teeth.

Clearance circle (or working depth circle): The circle tangent to the addendum circle of the mating gear. The radial distance between the addendum circle and the clearance circle is called the "working depth".

Clearance'd': The distance between the tooth top surface and the bottom surface of a mating gear.

Circular pitch 'p': The distance measured on the pitch circle from a point on one tooth to the corresponding point on an adjacent tooth. The circular pitch is equal to the sum of "tooth thickness" and "width of space". The width of space is slightly larger than the tooth thickness such that mating teeth can engage easily without obstruction.



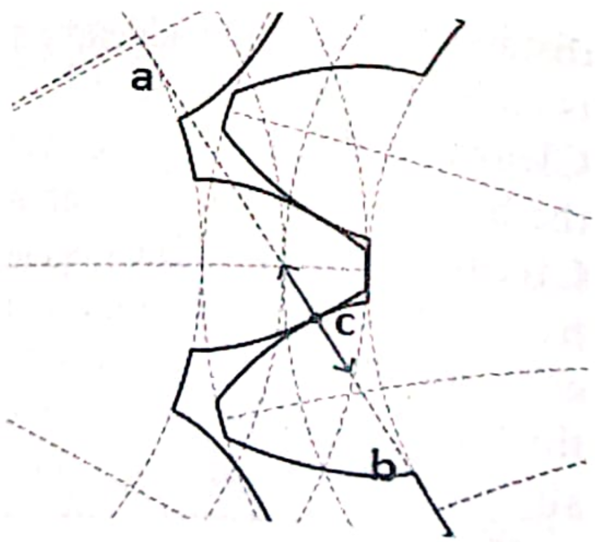
Module 'm': Module is the ratio of pitch diameter to the number of teeth of a gear.

Module m =d/N

Circular pitch p= $\pi d/N$

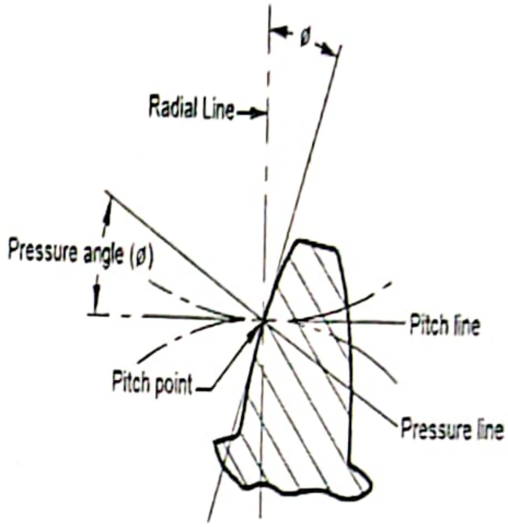
Diametral pitch 'p': The ratio of the number of teeth of a gear to the pitch diameter (it is the inverse of the module and it is used with gears sized in inches; its unit is 'teeth per inch').

$P = N/d = 1/m$ or, $p = \pi/P$



Pressure Line: During the meshing of gears, the contact between a pair of gear teeth occurs at a single instantaneous point. This point of contact (point c) occurs where the two surfaces are tangent to each other, and the forces will be directed along the common normal (line ab) which is also called the "Line of Action" or the "Pressure Line". Rotation of

the gears causes the location of the contact point (point c) to move across the respective tooth surfaces. For gear teeth having involute profiles, as the point of contact moves, it will move along the pressure line which remains at a constant angle.

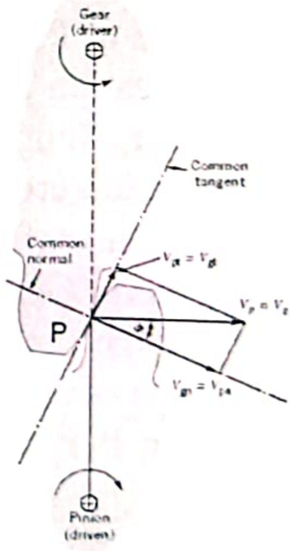


Pressure Angle: The angle between the pressure line and the pitch line is called the "Pressure Angle (Ø)".

17. What is Laws of Gearing?

Answer:

The law of gearing states that as the gears rotate, the common normal to the surfaces at the point of contact must always intersect the line of centers at the same point (P called the pitch point).



18. Define Gear Ratio.

Answer: The gear ratio "*R*" (also known as speed ratio) of a gear set is defined as the ratio of the angular velocity of the input gear (driver gear) relative to that of the output gear(driven gear).The gear ratio is simply equal to the ratio of

the number of teeth (or pitch diameters) of the driven gear relative to driver gear:

$$R = \frac{N_{driver}}{N_{driven}} = \frac{T_{driven}}{T_{driver}} = \frac{D_{driven}}{D_{driver}}$$

With this basic introduction, let us move on to see the various types of gears available. The types of gears to be used are determined based on the application in which they are to be used in.

19. What are the types of gear?

Answer:

1. Parallel Axis Gears: In this type of gearing, the axis of both the gears tends to be parallel to each other. The types of gears that come under this system of gears are:

* Spur Gears
* Helical Gears
* Double Helical or Herringbone Gears

Areas of application of Parallel Axis Gears:

Some typical application areas of **spur and helical** are automobile, gearboxes, industrial gearboxes etc.

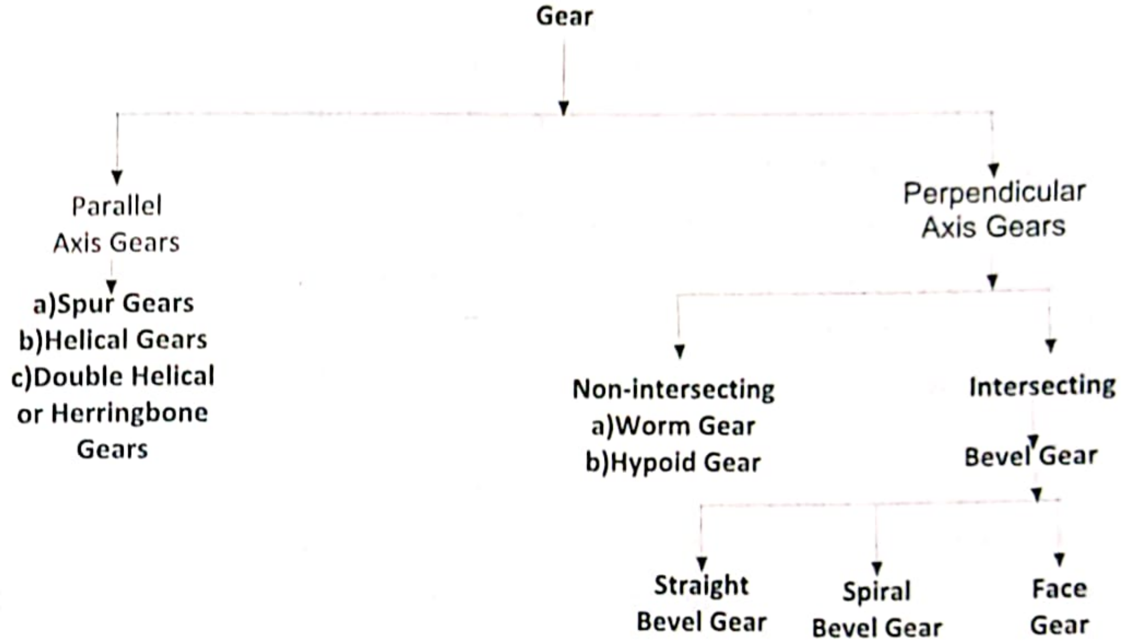
Some of the application areas of Herringbone gears are in the gearboxes used for steel rolling mills etc.

2. Perpendicular Axis Gears: In this type of gearing the axis of the gears tend to be perpendicular to each other. There are two types in this type of gearing too. They are

a) Non Intersecting Perpendicular Axis: In this type the two perpendicular axis of the gearing do not intersect each other.
The two types of gearing that fall under this category are –
Worm Gear and the hypoid gear.

Some typical applications of worm gears are in the passenger lifts used in the buildings. Another typical application of the Hypoid gear is in the rear axle of the buses, lorries and heavy vehicles.

b) Intersecting Perpendicular Axis Gears: In this type the perpendicular axis of the gears tend to intersect at a certain point. The types of gears that fall under this are the –
Straight Bevel Gears, Spiral Bevel Gears and Face Gears. Some typical applications of Straight bevel gear are the differential mechanism in the automobile.



20. Spur gear কি? এর ব্যবহারগুলো কি?

Answer: Supr gears have their teeth parallel to the axis and are used for transmitting power between two parallel shafts. They are simple in construction, easy to manufacture and less cost. They have highest efficiency and excellent precision rating.

Application: They are used in high speed and high load application in all types of trainsand a wide range of velocity ratios. Hence, they find wide applications right from clocks, household gadgets, motor cycles, automobiles, and railways to aircrafts.

21. Helical Gear কি? এর ব্যবহারগুলো কি?

Answer: Helical gears are used for parallel shaft drives. Hence for the same width, their teeth are longer than spur gears and have higher load carrying capacity. Their contact ratio is higher than spur gears and they operate smoother and quieter than

spur gears. Their precision rating is good. They are recommended for very high speeds and loads.

Application: These gears find wide applications in automotive gearboxes. Their efficiency is slightly lower than spur gears. The helix angle also introduces axial thrust on the shaft.

Double Helical Gear or Herringbone Gear:

Double helical or Herringbone gears used for transmitting power between two parallel shafts. They have opposing helical teeth with or without a gap depending on the manufacturing method adopted. Two axial thrusts oppose each other and nullify. Hence the shaft is free from any axial force. Though their load capacity is very high, manufacturing difficulty makes them costlier than single helical gear.

Application: Their applications are limited to high capacity reduction drives like that of cement mills and crushers.

22. Rack and Pinion কি? এর ব্যবহারগুলো কি?

Answer: Rack is a segment of a gear of infinite diameter. The tooth can be spur or helical. This type of gearing is used for converting rotary motion into translatory motion or vice versa. Typical example of rack and pinion applications are Lathe carriage drive mechanism and radial drilling machine spindle movement.

23. Bevel gear কি? এর সম্পর্কে বলো।

Answer: Straight bevel gears: Straight bevel gears are used for transmitting power between intersecting shafts. They can operate under high speeds and high loads. Their precision rating is fair to good. They are suitable for 1:1 and higher velocity ratios and for right-angle meshes to any other angles. Their good choice is for right angle drive of particularly low ratios. However, complicated both form and fabrication limits achievement of precision. They should be located at one of the less critical meshes of the train.

Application: Wide application of the straight bevel drives is in automotive differentials, right angle drives of blenders and

conveyors. A typical application of straight bevel used in differential application is in differential of an automobile.

Spiral bevel gears: Spiral bevel gears are also used for transmitting power between intersecting shafts. Because of the spiral tooth, the contact length is more and contact ratio is more. They operate smoother than straight bevel gears and have higher load capacity. But, their efficiency is slightly lower than straight bevel gear. Usage of spiral bevel gears in an automobile differential

Hypoid Bevel Gear: These gears are also used for right angle drive in which the axes do not intersect. This permits the lowering of the pinion axis which is an added advantage in automobile in avoiding hump inside the automobile drive line power transmission. However, the non-inter section introduces a considerable amount of sliding and the drive requires good lubrication to reduce the friction and wear. Their efficiency is lower than other two types of bevel gears. These gears are widely used in current day automobile drive line power transmission.

24. Worm gear কি? এর সম্পর্কে বলো।

Answer: Worm and worm gear pair consists of a worm, which is very similar to a screw and a worm gear. They are used in right-angle skew shafts. In these gears, the engagement occurs without any shock. The sliding action prevalent in the system while resulting in quieter operation produces considerable frictional heat. High reduction ratios 8 to 400 are possible. Efficiency of these gears is low anywhere from 90% to 40 %. Higher speed ratio gears are non-reversible. Their precision rating is fair to good. They need good lubrication for heat dissipation and for improving the efficiency. The drives are very compact.

Application: Worm gearing finds wide application in material handling and transportation machinery, machine tools, automobiles etc.

25. State the advantages and disadvantages of different types of gear.

Answer:

Spur Gear

Advantages

- They offer constant velocity ratio
- Spur gears are highly reliable
- Spur gears are simplest, hence easiest to design and manufacture
- A spur gear is more efficient if you compare it with helical gear of same size
- Spur gear teeth are parallel to its axis. Hence, spur gear train does not produce axial thrust. So the gear shafts can be mounted easily using ball bearings.
- They can be used to transmit large amount of power (of the order of 50,000 kW)

Disadvantages

- Spur gear are slow-speed gears
- Gear teeth experience a large amount of stress
- They cannot transfer power between non-parallel shafts
- They cannot be used for long distance power transmission.
- Spur gears produce a lot of noise when operating at high speeds.
- When compared with other types of gears, they are not as strong as them.

Helical Gear

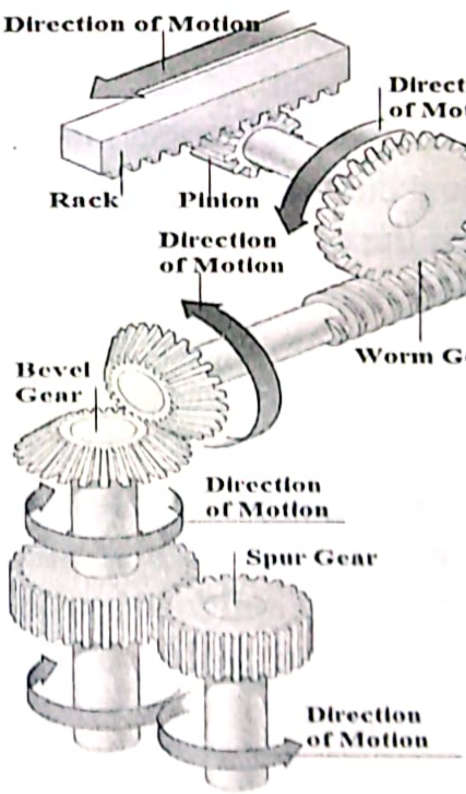
Advantages

- The angled teeth engage more gradually than do spur gear teeth causing them to run more smoothly and quietly
- Helical gears are highly durable and are ideal for high load applications.
- At any given time their load is distributed over several teeth, resulting in less wear

- Can transmit motion and power between either parallel or right angle shafts

Disadvantages

- An obvious disadvantage of the helical gears is a resultant thrust along the axis of the gear, which needs to be accommodated by appropriate thrust bearings, and a greater degree of sliding friction between the meshing teeth, often addressed with additives in the lubricant. Thus we can say that helical gears cause losses due to the unique geometry along the axis of the helical gear's shaft.
- Efficiency of helical gear is less because helical gear trains have sliding contacts between the teeth which in turns produce axial thrust of gear shafts and generate more heat. So, more power loss and less efficiency



Bevel Gear

Advantages

- This gear makes it possible to change the operating angle.
- Differing of the number of teeth (effectively diameter) on each wheel allows mechanical advantage to be changed. By

increasing or decreasing the ratio of teeth between the drive and driven wheels one may change the ratio of rotations between the two, meaning that the rotational drive and torque of the second wheel can be changed in relation to the first, with speed increasing and torque decreasing, or speed decreasing and torque increasing.

Disadvantages

- One wheel of such gear is designed to work with its complementary wheel and no other.
- Must be precisely mounted.
- The shafts' bearings must be capable of supporting significant forces.

Worm Gear

Advantages

- Worm gear drives operate silently and smoothly.
- They are self-locking.
- They occupy less space.
- They have good meshing effectiveness.
- They can be used for reducing speed and increasing torque.
- High velocity ratio of the order of 100 can be obtained in a single step

Disadvantages

- Worm gear materials are expensive.
- Worm drives have high power losses
- A disadvantage is the potential for considerable sliding action, leading to low efficiency
- They produce a lot of heat.

Rack and Pinion

Advantages

- Cheap
- Compact
- Robust
- Easiest way to convert rotation motion into linear motion
- Rack and pinion gives easier and more compact control over the vehicle

Disadvantages

- Since being the most ancient, the wheel is also the most convenient and somewhat more extensive in terms of energy too. Due to the apparent friction, you would already have guessed just how much of the power being input gives in terms of output, a lot of the force applied to the mechanism is burned up in overcoming friction, to be more precise somewhat around 80% of the overall force is burned to overcome one.
- The rack and pinion can only work with certain levels of friction. Too high a friction and the mechanism will be subject to wear more than usual and will require more force to operate.
- The most adverse disadvantage of rack and pinion would also be due to the inherent friction, the same force that actually makes things work in the mechanism. Due to the friction, it is under a constant wear, possibly needing replacement after a certain time.

The geometry of a standard spur gear is defined by four parameters; module (or diametral pitch), pressure angle, number of teeth, and face width. A standard ISO spur gear having a module of 4 mm, 25 teeth, 20° pressure angle, and 30 mm face width is designated as:

ISO- Spur gear 4M 25T 20PA 30FW.

26. Which operations are performed by Drilling machine, Lathe machine, Grinding machine, Milling Machine and Broaching Machine.

Answer: Drilling machine:

a. Counter boring
b. Counter sinking
c. Spot facing

Lathe machine:

a. Turning
b. Boring
c. Tapping

d. Facing
e. Knurling
f. Shaping

Grinding machine:

a. Surface finishing
b. Facing
c. Cylindrical grinding
d. High efficiency deep grinding (HEDG)

Milling machine:

a. Machining of curved, flat, circular surfaces.

Broaching machine: Broaching is machining process that pushes or pulls cutting tool (called a broach) over or through the surface being machined. A broach is a series of single-point tools arranged successively in the axial direction along a tool body or holder.

a. Straddle broaching
b. Slot broaching
c. Internal broaching

Industries that utilize broaching:

- Aerospace
- Automotive
- Appliance
- Firearms
- Locks
- Defense
- Mining Equipment
- Medical

27. Which operations are possible to do by a drilling machine?

Answer:

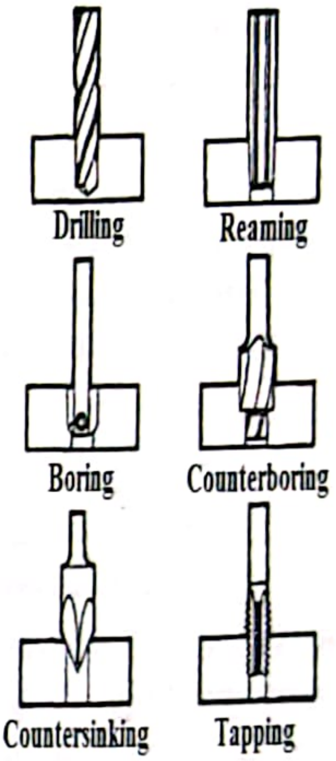
Reaming: To finish a hole to size with a reamer.

Boring: The operation of enlarging an existing hole in a work piece to produce a better finish and size.

Counter boring: The operation of enlarging a portion of a hole for part of its depth and to a given diameter.

Counter sinking: The operation of enlarging the top portion of a hole to a conical shape. Example: The head of a flathead screw.

Tapping the operation of producing threads in holes using taps as the cutting tools may be done by hand or machine.



28. Main parts of Drill machine, lathe machine and milling machine.

Answer:

Lathe Machine: A lathe is a device in which one object which is in rotatory motion is machined when a cutting tool is feed to it in an axis parallel to its axis of rotation.

Main Parts:

a) Bed b) Head-stoke c) Tail-stoke d) Carriage e) Feed mechanism and f) Thread-cutting mechanism.

Drill Machine: A drilling machine is a tool used for drilling holes in various types of wood, plastic and metal.

Main Parts:

a) Base b) Column c) Table and d) Head

Milling Machine: A milling machine is one that is designed to remove metal or other material from a piece of work with a revolving cutter as the work is fed against it.

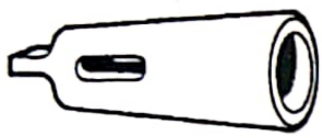
Main Parts:

a) Base b) Column c) Knee d) Table e) Spindle and f) Overarm

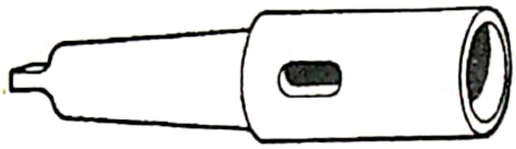
29. What is drill sleeve and drill socket?

Answer: Drill sleeve: A drill sleeve is used when the taper shank on a drill is smaller than the taper hole in the spindle.

Drill socket: A drill socket is used when the taper shank of a drill is larger than the taper hole in the spindle.



DRILL SLEEVE



DRILL SOCKET

30. What is Tap and Die?

Answer: Tap: A harden and tempered steel tool for cutting internal threads which has flutes lengthwise to provide cutting edges for the threads and a square at the end of the shank for turning the tap with a wrench.

Die: The name of a tool used to cut screw threads on the outside of a cylinder.

31. What is Homogenous and isotropic material?

Answer: Homogenous: A homogeneous material means a material which has uniform composition and uniform properties throughout. Metals, alloys, ceramics are examples of homogeneous materials. Air, salt solution etc. are examples of homogeneous mixtures. In addition, an alloy is a solid solution, which is a homogeneous solid mixture of two metals.

Isotropic: Isotropic means that the properties of materials are the same in all directions. In processes, the rate of process is the same in all directions.

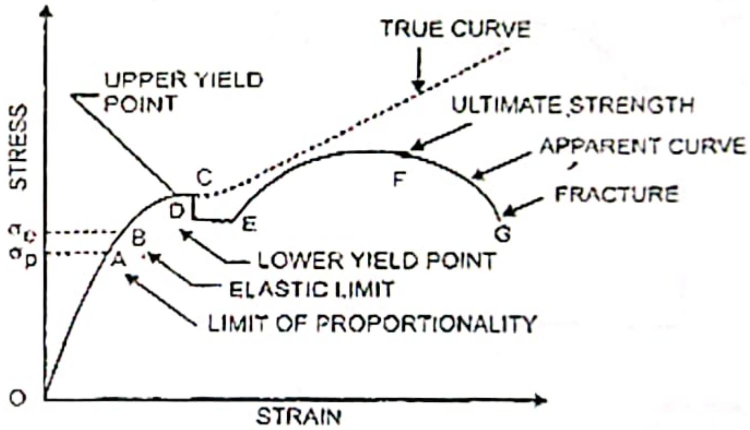
32. What is the difference between Homogeneous and Isotropic?

Answer:

- Homogeneous is uniformity throughout and isotropic means uniformity of properties in all directions.
- Isotropy is based on the direction of properties; but homogeneity does not depend on the direction.

33. What is the difference between MS, CS, HCS, HSS and GI?

Answer: MS (Mild Steel): Iron-carbon alloy is containing less than 0.25 percent carbon which makes it more ductile and less hard thus rendering it unsuitable for structural work.



Stress-strain diagram for mild steel.

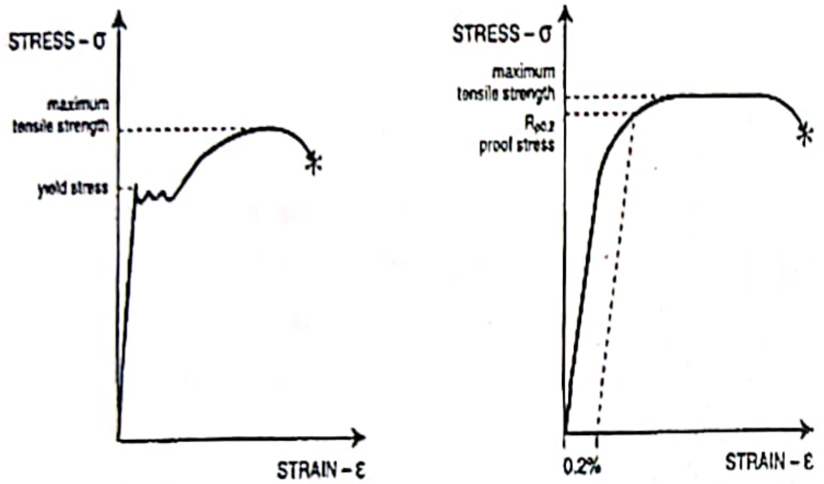
CS (Carbon Steel): One of several types of iron (such as gray iron and white iron) containing 1.8 to 4.5 percent carbon by weight whereas carbon steel contains less than 0.5 percent. The additional carbon makes the molten iron more fluid and easier to cast in complex shapes. Highly suitable for casting large and heavy objects (such as engine blocks) it has high compression strength but low ductility.

HCS (High Carbon Steel): High Carbon Steels are carbon steels which have iron and a carbon content of around 0.6-1.5% by weight. Due to the higher carbon contant compared to low and medium carbon steels, the high carbon steel has higher hardness but lower ductility, lower weldability and higher brittleness.

Because of its high hardness and wear resistance they are used in cutting tools and masonry nails. They are also be used in springs, wires, swords etc.

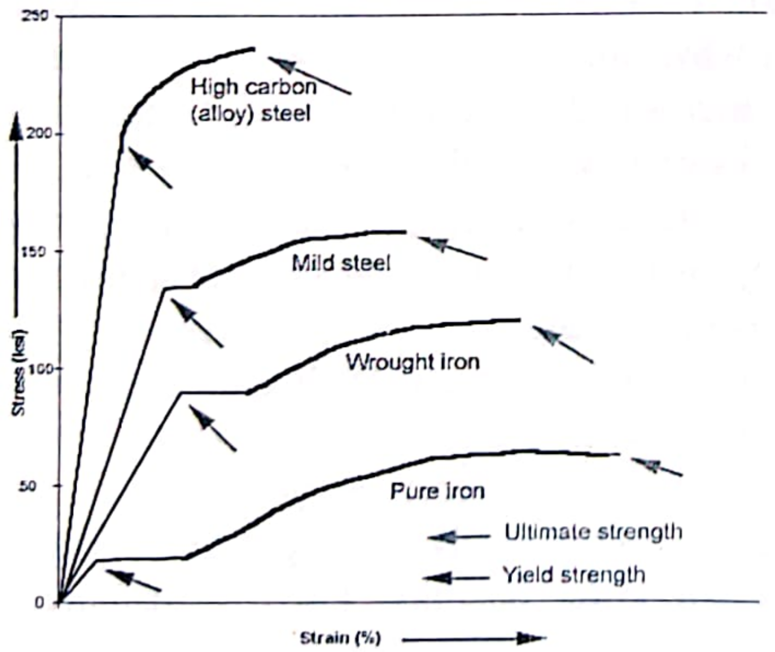
HSS (High Speed Steel): Low (generally 0.3 to 0.7 percent) carbon steels that remain hard at dull-red heat generated in machining operations. They typically contain 5 percent chromium and 10 to 20 percent tungsten, and may also contain small amounts of cobalt and/or vanadium. Used mainly for dies, drill bits, reamers, saw blades, and taps.

GI- Galvanized Iron that is coated with zinc to protect it from rust.



(a) Carbon steel (b) Stainless steel

Comparative Stress/Strain Diagram



34. What is bearing?

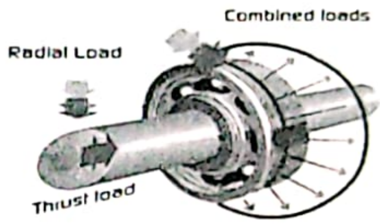
Answer: Any bearing can be simply defined as a support or guide which at the same time allows relative movement to take place between two bodies.

- A bearing is a component used to reduce friction in a machine.
- Carry load in one or several directions while allowing frictionless motion in other directions.

35. Classify Bearing.

Answer: Classification of Bearings

- According to rolling elements: Ball and Roller bearings
- According to the direction of load: Radial and Thrust bearings



- According to contact: Rolling contact and Journal (sleeve) bearings
- Another class is: Antifriction (Ball and roller) and Journal Bearing

Rolling contact bearing

Rolling contact bearings are also called anti-friction bearing due to its law friction characteristics. These bearings are used for radial load, thrust load and combination of thrust and radial load. These bearings are extensively used due to its relatively lower price, being almost maintenance free and for its operational ease. However, friction increases at high speeds for rolling contact bearings and it may be noisy while running. These bearings are of two types,

(a) Ball bearing

(b) Roller bearing

The disadvantage of the ball and roller bearings are high cost, they cannot be used in half, and greater noise.

Ball Bearing: Ball bearing is normally known as anti-friction bearing. A number of steel balls are held between an inner race, or bearing surface and an outer race. A retainer ring keeps the balls spaced equally between the races. These types of bearings are used in these machineries where loads are not too heavy.

Ball bearings are extremely common because they can handle both **radial and thrust loads**, but can only handle a small amount of weight.

Types of ball bearing:

- Deep groove ball bearing
- Double deep groove bearing
- Angular contact ball bearing
- Thrust bearing

Roller bearing: Roller bearing has higher load capacity than ball bearings, load is transmitted through line contact instead of point contact.

Types of roller bearing

Roller Thrust Bearings

Roller Thrust Bearings are used to support thrust loads in car transmission between gears, in between housing and the rotating shafts, etc.

Tapered Roller Bearings

Tapered roller bearings are used in car hubs, where they are usually mounted in pairs facing opposite directions so that they can handle thrust in both directions.

Spherical bearings

This type of bearing consists of spherical outer race with two tracks, a cage, and a complement of spherical shaped rollers.

Needle roller bearing

- Needle roller bearings use needle rollers as rolling elements.
- The needle rollers are a maximum of 5mm in diameter and are 3 to 10 times as long as they are in diameter.

They have a high load capacity for their size. Because of the large number of rolling elements, the bearings have high rigidity and are ideally suited to wobbling or pivoting motion.

Journal bearing:

- It is simply a block of cast iron with a hole for the shaft providing running fit. An oil hole is drilled at the top for lubrication.
- The main disadvantage of this type of bearing are

  -There is no provision for wear and adjustment on account of wear.

  -The shaft must be passed into the bearing axially, i.e. endwise.

  -Limited load on shaft and speed of shaft is low.

It is also known as **sleeve bearing**. In this bearing load is transferred through a lubricant in sliding contact.

Journal bearings are of two types

a) Hydrodynamic bearing

b) Hydrostatic bearing: Hydrostatic lubrication bearings requiring lubricants that elevates the rotating shaft by providing the pressurized lubricant from outside.

Antifriction Bearing

The types of antifriction bearing (axial ball, roller and thrust bearings) are group by the shape of the rolling element and they are-Ball bearings, Cylindrical roller bearings, Tapered roller bearings, and Needle roller bearings.

36. Show that the product of diametral pitch and module is equal to π.

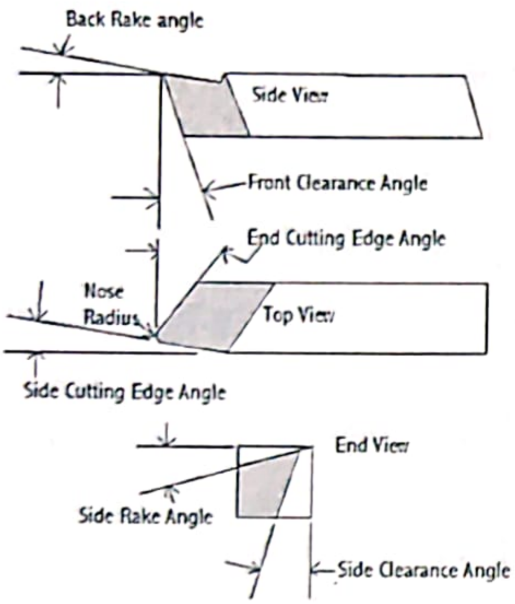
Solution: We know, Diametral Pitch, $P_d = T/D$

And Circular pitch, $P_c = \pi D/T$

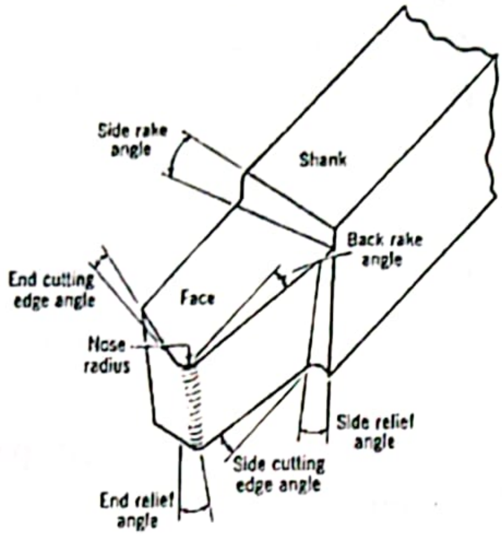
$\therefore P_d \times P_c = T/D \times \pi D/T = \pi$ (Shown)

37. Draw a single point cutting tool.

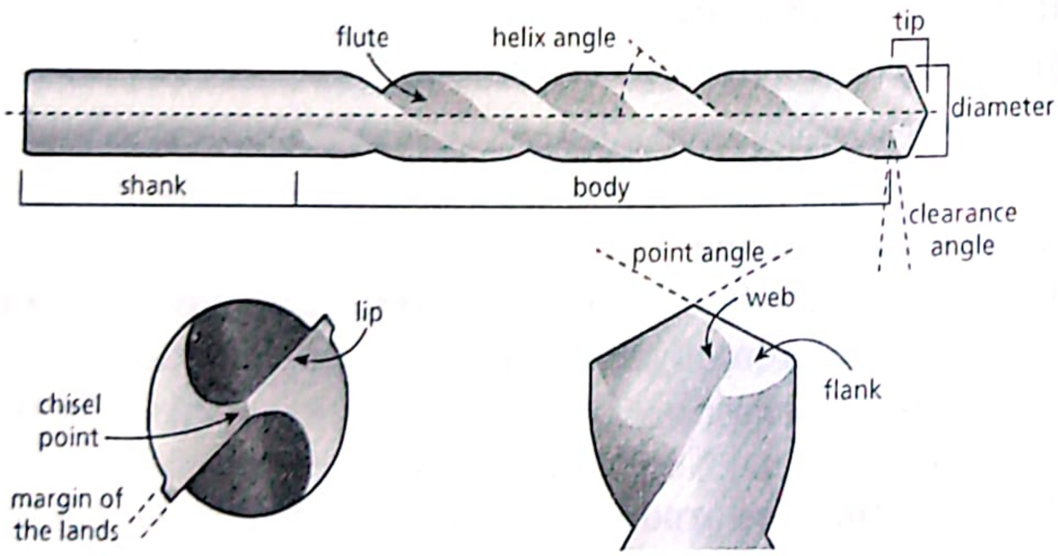
Tool Bit Geometry



Lathe tool (single point cutting tool)



38. Draw a twist drill bit.



39. What is the difference between critical speed and whirling speed?

Answer: For a rotating mass such as- a shaft, propeller or gear, the critical speed is the theoretical angular velocity, which exceeds the natural frequency of that rotating object. As the speed of rotation approaches the objects natural frequency, the object begins to resonate which consequently increases system

vibration. The resulting resonance occurs regardless of orientation. On the otherhand, Whirling Speed is due to the unbalanced forces acting on a rotating shaft.

40. What is a spring?

Answer: A spring is an elastic member, which deflects, or distorts under the action of load and regains its original shape after the load is removed.

41. State any two functions of springs.

Answer: 1. To measure forces in spring balance, meters and engine indicators.

2. To store energy.

42. What are the various types of springs?

Answer:

1. Helical springs
2. Spiral springs
3. Leaf springs
4. Disc spring or Belleville springs

43. Define Leaf springs

Answer: A leaf spring consists of flat bars of varying lengths clamped together and supported at both ends, thus acting as a simply supported beam.

44. What is spring index (C)?

Answer: The ratio of mean or pitch diameter to the diameter of wire for the spring is called the spring index.

45. What is pitch?

Answer: The axial distance between adjacent coils in uncompressed state.

46. What is solid length?

Answer: The length of a spring under the maximum compression is called its solid length. It is the product of total number of coils and the diameter of wire. $L_s = n_t \times d$

Where, n_t = total number of coils, d= diameter of the wire

47. What is buckling of springs?

Answer: The helical compression spring behaves like a column and buckles at a comparative small load when the

length of the spring is more than 4 times the mean coil diameter.

48. What are the various applications of springs?

Answer: The springs are used in various applications, they are-

1. Used to absorb energy or shocks (e.g. shock absorbers, buffers, etc.)
2. To apply forces as in brakes, clutches, spring-loaded valves etc.
3. To measure forces as in spring balances and engine indicators
4. To store energy as in watches

49. Define free length.

Answer: Free length of the spring is the length of the spring when it is free or unloaded condition. It is equal to the solid length plus the maximum deflection or compression plus clash allowance.

L_f = Solid length + Y_{max} + 0.15 Y_{max}

50. Define spring index.

Answer: Spring index (C) is defined as the ratio of the mean diameter of the coil to the diameter of the wire. C =D/d

51. Define fatigue.

Answer: When a material is subjected to repeated stress, it fails at stresses below the yield point stress; such type of failure of the material is called fatigue.

52. Define Factor of safety.

Answer: The ratio between maximum stresses to working stress is known as factor of safety.

Factor of safety = Maximum stress /Working stress

53. Define endurance limit.

Answer: Endurance limit is the maximum value of completely reversed stress that the standard specimen can sustain an infinite number (10^6) of cycles without failure.

54. What is impact load?

Answer: If the time of load application is less than one third of the lowest natural period of vibration of the part, it is called an impact load.

55. What are the types of variable stresses?

Answer: Types of variable stresses are:

1. Completely reversed or cyclic stresses
2. Fluctuating stresses
3. Repeated stresses

56. Define stress concentration and stress concentration factor.

Answer: Stress concentration is the increase in local stresses at points of rapid change in cross section or discontinuities. Stress concentration factor is the ratio of maximum stress at critical section to the nominal stress.

57. Explain size factor in endurance strength.

Answer: Size factor is used to consider the effect of the size on endurance strength. A large size object will have more defects compared to a small one. So, endurance strength is reduced. If K is the size factor, then

Actual endurance strength = Theoretical endurance limit$\times K$

58. What are various theories of failure?

Answer: The failure theories are:

1. Maximum principal stress theory.
2. Maximum shear stress theory.
3. Maximum principal strain theory.

59. List out the factors involved in arriving at factor of safety.

Answer: The factors involved in arriving at factor of safety are: 1. Material properties

2. Nature of loads
3. Presence of localized stresses
4. Mode of failures

60. Give some methods of reducing stress concentration.

Answer: Some of the methods are:

1. Avoiding sharp corners.
2. Providing fillets.
3. Use of multiple holes instead of single hole
4. Undercutting the shoulder parts.

61. Explain notch sensitivity. State the relation between stress concentration factor and notch sensitivity.

Answer: Notch sensitivity (q) is the degree to which the theoretical effect of stress concentration is actually reached. The relation is, $K_f = 1 + q\,(K_t - 1)$

62. What are the factors that affect notch sensitivity?

Answer: The factors effecting notch sensitivity are:

1. Material
2. Notch radius
3. Size of component
4. Type of loading
5. Grain Structure

63. What is the use of Goodman & Soderberg diagrams?

Answer: They are used to solve the problems of variable stresses.

64. Define machinability.

Answer: It is the property of the material, which refers to a relative ease with which a material can be cut. It is measured in a number of ways such as comparing the tool life for cutting different material.

65. What is an S-N Curve?

Answer: An S- N curve has fatigue stress on 'Y' axis and number of loading cycles in '*X*' axis. It is used to find the fatigue stress value corresponding to a given number of cycles.

66. What is principle stress and principle plane?

Answer: A plane which has no shear stress is called principle plane the corresponding stress is called principle stress.

67. Write the bending equation.

Answer: The bending moment equation is, $M/I = f/y = E/R$,

Where, M – Bending moment (M is in N-mm)

I - Moment of inertia about centroidal axis (I is in mm^4)

f – Bending Stress (f is in N/mm^2)

y - Distance from neutral axis (y is in mm)

E - Young's modulus (E is in N/mm^2)

R - Radius of curvature (R is in mm)

68. Write the torsion equation.

Answer: The torsional equation is, $T/J = q/r = G\Theta/L$

Where,

T – Torsional moment (T is in N-mm)

J - Polar moment of inertia (J is in mm^4)

q – Shear stress in the element (q is in N/mm^2)

r - Distance of element from centre of shaft (r is in mm)

G- Modulus of Rigidity (G is in N/mm^2)

Θ – Angle of twist (Θ is in radians)

L – Length of the shaft (L is in mm)

69. What is the difference between S.S to EN8?

Answer: SS- Stainless steel

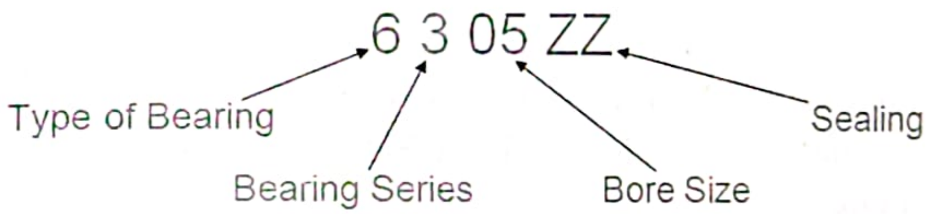
En- Medium carbon steel

SS is Non Magnetic material and EN8 is Magnetic material

SS is Corrosion resistant and EN8 is Magnetic material.

70. Explain the nomenclature of Ball Bearing.

Answer:



Types of Bearings and Their Code in Bearing Number

Type Code	Bearing Name
1	Self Aligning Ball Bearing
2	Spherical Rollar Bearing
3	Double row angular contact ball bearing
4	Double row ball bearing
5	Thrust Ball Bearing
6	Single row deep groove ball bearing
7	Single row angular contact bearing
8	Felt seal bearing
32/T	Tapered Roller Bearing
R	Inch Bearing
N	Cylindrical roller bearing

NN	Double Row Roller Bearing
NA	Needle Roller Bearing
BK	Needle Roller Bearing with closed end (Drawn Cup)
HK	Needle Roller Bearing with opened end (Drawn Cup)
C	CARB toroidal roller bearing
K	Needle roller and cage thrust assembly
QJ	Four Point Contact Ball Bearing

Series (Toughness) of Bearing

Series Code	Series Description
0	Extra Light
1	Extra Light Thrust
2	Light
3	Medium
4	Heavy
8	Extra thin Section
9	Very thin section

Bore size of bearing

Third and Fourth Digit	Bore Size (in mm)
00	10
01	12
02	15
03	17
04	(×5) 20
05	(×5) 25

Sealing

Z	One side shielded
ZZ	Both sides shielded
RS	One side sealed
2RS	Both sides sealed
V	One side non contact seal

VV	Both sides non contact seal
DDU	Both sides contact seal
NR	Snap ring and groove
M	Brass cage

71. What is abrasive?

Answer: A natural or artificial material such as sandstone, emery, aluminum oxide, or silicon carbide. Used for making grinding wheels, abrasive cloth, and lapping compounds.

72. What is blind hole?

Answer: A hole, which is made to a certain depth of a workpiece but does not pass through it.

73. Define boring.

Answer: The operation of enlarging an existing hole in a workpiece to produce a better finish and size. A hole maybe bored straight or tapered, or it may have steps or shoulders.

74. Define buffing.

Answer: The operation of further polishing or finishing a metal to a very smooth surface and a high luster. The work is held against a buffing wheel of cloth, felt, or leather, to which a compound containing an abrasive is applied.

75. What is climb-cut milling?

Answer: Work fed into the direction of rotation of a milling cutter rather than against the rotation of cutter. Also, called down milling or incut milling.

76. Define dressing.

Answer: An operation performed on a grinding wheel to make it cut better. This is done by passing a suitable wheel dresser toll across the face of the grinding wheel. This, in turn, removes metal particles and dulled abrasive, leaving a clean, sharp wheel face.

77. What is indexing?

Answer: A process of dividing circular or other shapes of workpieces into equal spaces, divisions, or angles, using an index or dividing head.

78. Define lapping.

Answer: A process of precision finishing with fine abrasive such as diamond powder or abrasive flours. May be done by hand or machine to improve the size, shape, and surface of workpieces, especially those that have been hardened.

79. What is straight turning?

Answer: The operation of turning work in the lathe so that the length of each diameter is uniform or the same size from end to end.

80. What is taper turning?

Answer: The operation of turning a taper in an engine lathe using either the compound slide, tailstock offset, or taper attachment.

81. What up-milling means?

Answer: Refers to the direction of feed when milling a workpiece in which the cutter is rotated against the direction of travel or feed of the workpiece. Also called conventional or outcut milling.

81. What is welding?

Answer: Welding is a fabrication process that joins usually two metal parts by using high heat to melt the metal parts together and allowing them to cool causing fusion.

82. What are the main components for welding process?

Answer: Power source, controls, wire feeder, welding gun, gas(if needed) etc.

83. Why welding is preferable than other joining processes?

Answer: Easy operation, great strength, high efficiency.

84. What do you mean by SMAW,MIG,TIG welding?

Answer: Shielded Metal Arc Welding, Metal Inert Gas welding, Tungsten Inert Gas welding.

85. What is TIG welding?

Answer: TIG welding is an arc welding process that use a no consumable tungsten electrode to produce the weld.

86. What is MIG welding?

Answer: MIG welding is a process of welding in which a consumable metal wire is used as electrode and a inert gas is used as shield.

87. What is homogeneous and Heterogeneous welding?

Answer: In Homogeneous welding the metallurgical composition of filler metal is almost same as the base metal but metallurgical composition is substantially different from base metal in heterogeneous welding.

88. What are the most common gases use in Gas welding?

Answer: Oxygen and Acetylene.

89. How many temperature generated in Gas welding?

Answer: 3200°C.

90. Write down the types of flames generated in welding.

Answer: 1. Oxidizing, 2. Carburizing, 3. Neutral

91. Why Flux is used in welding?

Answer: To remove metal oxides , stabilize arc, control cooling rate.

92. Which materials are used for Flux formation?

Answer: Borax or mixture of fluoride and chlorides of Na, P, Li.

93. How much temperature generated in Electric Arc welding?

Answer: Average 6000-7000°C.

94. Why chipping hammer is used in welding?

Answer: To remove solidified slag after completion the welding process.

95. How arc length should be maintained?

Answer: 3 to 4 mm.

96. What are the types of Electrode with the base of coating?

Answer: 1. Coated electrode 2. Bare electrode.

97. Which gas is usually used as inert gas in MIG and TIG welding?

Answer: Argon.

98. How PAW is done?

Answer: Plasma from the torch forced through a fine-bore copper nozzle which constricts arc and welding is done.

99. Temperature in Plasma Arc Welding = ?

Answer: 20,000°C.

100. What are the welding positions are mainly followed?

Answer: 1. Down hand welding position 2. Horizontal welding position 3. Vertical welding position 4. Overhead welding position.

101. What are the Arc welding defects?

Answer: Lack of penetration, Porosity, Cracking, Slag inclusion etc.

102. What is spot welding?

Answer: The welding of overlapping pieces of metal at small points by application of pressure and electric current.

103. What is laser beam welding?

Answer: LBW is welding technique used to join pieces of metal by use of Laser as a heat source.

104. What are the main types of joints in welding process?

Answer: Butt joint, T-joint, Corner joint, Edge joint.

105. What is Soldering?

Answer: It is a process of join two metal parts with another low metal alloy(melting temperature below 400°C)

106. What is Brazing?

Answer: Brazing is a joining process with heating and adding non-ferrous alloy (melting point above 400°C)

107. Which create more stronger joint: Soldering / Brazing?

Answer: Brazing.

108. Why pre and post heating is done on pipe in welding process?

Answer: To maintain uniform structure.

109. What are the tests of Welding?

Answer: There are two types of welding tests-

1. Destructive and 2. Non-destructive

1. Destructive

• Physical damage to w/p and welded join.

• Quantitative data obtained

2. Non Destructive

• Without physically damaging the workpiece and joint.

• Qualitative data is obtained.

110. What are the destructive Weld Testing?

Answer: • Tensile Test

• Bend Test

• Hardness Test

• Toughness Testing

• Fatigue Behavior

111. What are the common types of non destructive tests performed?

Answer: Major types of NDT

• Detection of surface flaws

-Visual Test (VT)

-Magnetic Particle Inspection

- Dye Penetrant Inspection (DPI) or Penetration Test (PT)

• Detection of internal flaws

- Radiography

-Ultrasonic Testing (UT)

-Eddy current Testing

112. What are the steps of Dye Penetration Test?

Answer: Apply- 1.Cleaner

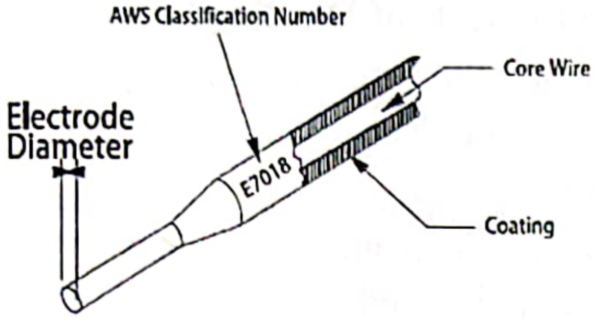
2. Penetrant + Dwell

3. Developer

4. Dwell

113. Define the electrode nomenclature E7018-X.

Answer:



E- Indicates an Electrode.

70- Indicates tensile strength. Measured in thousands of pounds per square inch.

1- Indicates welding position.

8- Indicates the coating, penetration, and current type used.

X- Indicates that there are more requirements.

Welding Positions:

1 All positions (Flat, Horizontal, Vertical (up), Overhead)

2 Flat, Horizontal

4 Flat, Horizontal, Overhead, Vertical (down)

Additional Requirement

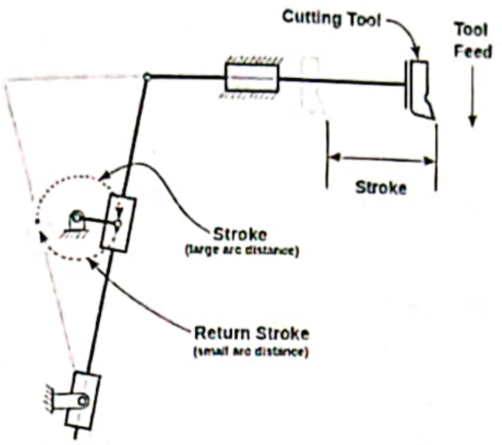
-1 Increased toughness (impact strength).

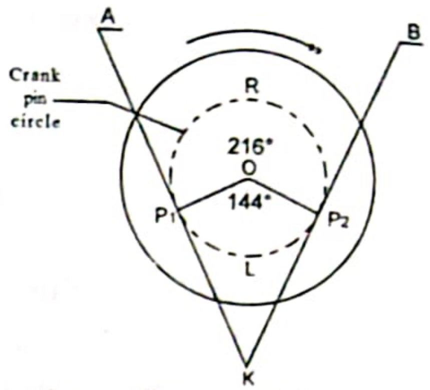
-M Meets most military requirements-greater toughness, lower moisture content as received after exposure, diffusible hydrogen limits for weld metal.

-H4, -H8, -H16: Indicates the maximum diffusible hydrogen limit measured in millimeters per 100 grams (mL/100g). The 4, 8, and 16 indicates what the limit is. Example: -H4 = 4mL per 100 grams

114. What is Quick Return Mechanism?

Answer: The ram moves at a comparatively slower speed during the forward cutting stroke. During the return stroke, the mechanism is so designed to make the tool move at a faster rate to reduce the idle return time. This mechanism is known as quick return mechanism.





Quick Return Mechanism of the Ram

115. Deffenciate between welding, soldering and brazing.

Answer:

Welding	Soldering	Brazing
1. Welding joints are strongest joints used to bear the load. Strength of the welded portion of joint is usually more than the strength of base metal.	1. Soldering joints are weakest joints out of three. Not meant to bear the load. Use to make electrical contacts generally.	1. Brazing joints are weaker than welding joints but stronger than soldering joints. This can be used to bear the load up to some extent.
2.Temperature required is 3800°C in welding joints.	2.Temperature requirement is up to 450°C in soldering joints.	2. Temperature may go to 600°C in brazing joints.
3. To join work pieces need to be heated till their melting point.	3. Heating of the work pieces is not required.	3. Work pieces are heated but below their melting point.
4. Mechanical properties of base metal may change at the joint due to heating and cooling.	4. No change in mechanical properties after joining.	4. May change in mechanical properties of joint but it is almost negligible.
5. Heat cost is involved and high skill level is required.	5. Cost involved and skill requirements are very low.	5. Cost involved and sill required are in between other two.
6. Heat treatment is generally required to eliminate undesirable effects of welding.	6. No heat treatment is required.	6. No heat treatment is required after brazing.
7. No preheating of work piece is required before welding as it is carried out at high temperature.	7. Preheating of work pieces before soldering is good for making good quality joint.	7. Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature.

116. What is WPS and WQR?

Answer: WPS-Welding Procedure Specification.

WQR-Welder Qualification Record.

117. What is the difference between pipe and tube?

Answer:

1. Pipes: The most important dimensions for a pipe is the outer diameter (OD) together with the wall thickness (WT). OD minus 2 times WT (SCHEDULE) determine the inside diameter (ID) of a pipe, which determines the liquid capacity of the pipe. The NPS(Nominal Pipe Schedule) does not match the true diameter, it is a rough indication.

Tubes: The most important dimensions for a steel tube are the outside diameter (OD) and the wall thickness (WT). These parameters are expressed in inches or millimeters and express the true dimensional value of the hollow section.

2. Pipes: The thickness of a steel pipe is designated with a 'Schedule' value (the most common are Sch. 40, Sch. STD., Sch. XS, Sch. XXS). Two pipes of different NPS and same schedule have different wall thicknesses in inches or millimeters.

Tubes: The wall thickness of a steel tube is expressed in inches or millimeters. For tubing, the wall thickness is measured also with a gage nomenclature.

3. Pipes are round only and Tubes are round, rectangular, square, oval.

4. Pipes are used in process lines and utility lines.

Tubes are used in tracing lines, heat exchangers and fired heaters and instrument connections.

118. What is the difference between seamless pipe and seam pipe?

Answer: The difference between seam and seamless pipe is in manufacturing process. Seamless pipe is made by extrusion process i.e molten metal is passed through die to get shape of pipe. These pipe have good Outer diameter with no mark of joints. They are used in application where pipe needs to be passed through fixed hole.

Seam pipes are made by seam or electric resistant welding process i.e sheet of steel is rolled in a shape of pipe and its sides are welded through electric resistance welding. Seam pipe don't have good outer diameter finish as there is thin line of welding on it

119. Elaborate SAE, AISI, ASME, API, ASTM.

Answer:

SAE- Society of Automobile Engineers

AISI-American Iron and Steel Institute

ASME-American Society of Mechanical Engineers

API-American Petroleum Institute

ASTM-American Society for Testing and Materials

120. What are the types of gear trains?

Answer: The gear train is classified into following types,

- Simple gear train.
- Compound gear train.
- Riveted gear train.
- Epicyclic gear train.

121. What is idle gear? What are the purposes of an idle gear?

Answer: we see that the speed ratio and the train value, in a simple train of gears, is independent of the size and number of intermediate gears. These intermediate gears are called idle gears, as they do not affect the speed ratio or train value of the system. The idle gears are used for the following two purposes:

1. To connect gears where a large centre distance is required, and

2. To obtain the desired direction of motion of the driven gear (i.e. clockwise or anticlockwise).

122. Write some applications of epicyclic train?

Answer: The epicyclic gear trains are useful for transmitting high velocity ratios with gears of moderate size in a comparatively lesser space. The epicyclic gear trains are used in the back gear of lathe, differential gears of the automobiles, hoists, pulley blocks, wrist watches etc.

অধ্যায় ৯
Automobile Engineering

1. What is Automobile?

Answer: The automobile is a self-propelled vehicle that travels on land. It usually has four wheels. An engine provides the power to the vehicle. The automobile, or car, carries people primarily for their personal transportation.

2. What are the basic parts and systems of an automobile?

Answer: Basic parts or major components include,

1) An engine, or power plant, that produce power to move the vehicle.

2) A power train, to carry the power from the engine to the drive wheels.

3) A suspension system that absorbs the shock of the tires and wheels meeting bumps and holes in the road.

4) A steering system, so the driver can control the direction of vehicle travel.

5) A braking system. So the driver can slow and stop the vehicle.

6) An electrical system, to provide electricity for cranking the engine, charging the battery, and powering the lights and other electrical equipment.

7) A body, that provides enclosures or compartments for the engine passengers, and luggage or cargo.

3. What are the basic engine systems?

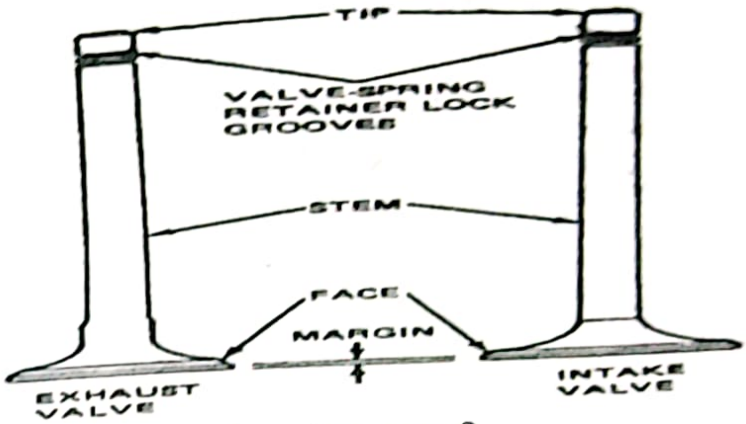
Answer:

1) Fuel system.

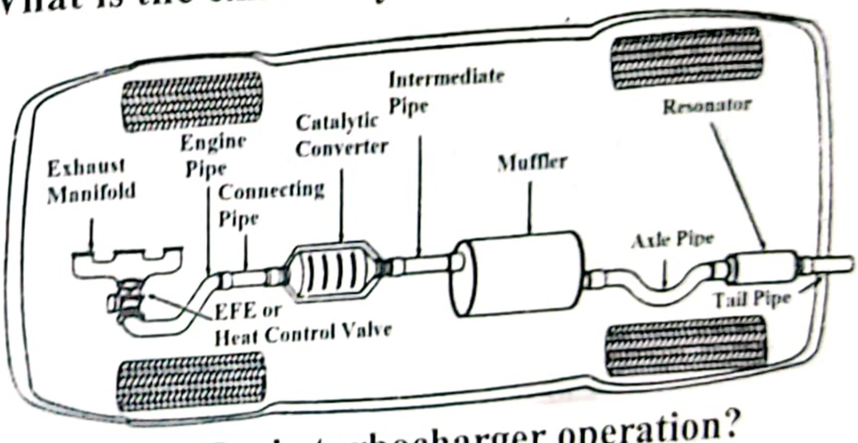
2) Electric ignition system (except diesel).
3) Lubrication system.
4) Cooling system.

4. What is the difference between inlet and exhaust valve?

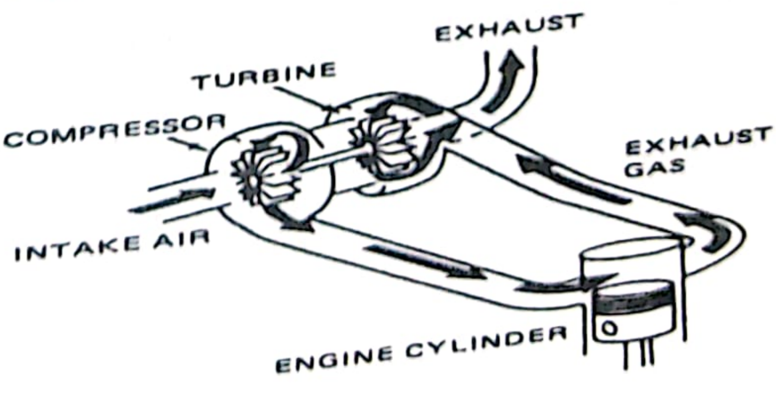
Answer: The intake valve is usually larger than the exhaust valve. The reason is that when the intake valve is open, the only force moving air-fuel mixture into the cylinder id atmospheric pressure. When exhaust valve opens on the exhaust stroke, there is still high pressure in the engine cylinder.



5. What is the exhaust system?



6. What is the Basic turbocharger operation?



7. What are the gasoline fuel injection system in gasoline engine.

Answer: There are two types of gasoline fuel-injection systems.

1) Port fuel injection (PFI) which has an injection valve or fuel injector in each intake port.

2) Throttle-body fuel injection (TBI) in which one or two fuel injectors are located above the throttle valves.

8. What are the properties of lubricating oil?

Answer:

1) Proper viscosity.
2) Viscosity index.
3) Viscosity numbers.
4) Multiple-viscosity oil.
5) Resistance to carbon formation and oil oxidation.
6) Corrosion and rust inhibitors.
7) Forming resistance.
8) Detergent-dispersants.
9) Extreme pressure resistance.
10) Energy conserving oil.
11) Synthetic oil.

9. What are the basic parts of cooling system?

Answer:

1) Water jacket.
2) Water pump.
3) Thermostat.
4) Radiator.
5) Fan

10. What are the automotive emission control systems?

Answer:

1) Positive crankcase ventilation (PCV).
2) Evaporative emission control.
3) Exhaust emission control.

11. What are the functions of the clutch?

Answer:

1) It can be disengaged (clutch pedal down). This allows engine cranking and permits the engine to run freely without delivering power to the transmission.

2) While disengaged (clutch pedal down), it permits the driver to shift the transmission into various gears. This allows the driver to select the proper gear (first, second, third, fourth, fifth, reverse or neutral) for the operating condition.

3) While engaging (clutch pedal moving up), the clutch slips momentarily. This provides smooth engagement and lessens the shock on gears, shafts and other drive-train parts. As the engine develops enough torque to develop the inertia of the vehicle, the drive wheel turns, and the vehicle begins to move.

4) When engaged (clutch pedal up), the clutch transmits power from the engine to the transmission. All slipping has stopped.

12. What are the purposes of the suspension system?

Answer:

1) Support the weight of the vehicle.
2) Cushion bumps and holes in the road.
3) Maintain traction between the tires and the road.
4) Hold the wheels in alignment.

13. What are the types of automotive springs?

Answer:

1) Coil spring.
2) Leaf spring.
3) Torsion bar.
4) Air spring.

14. What is Camber?

Answer: Camber is the inward or outward tilt of a wheel from the vertical when viewed from the front of the vehicle. A wheel that tilts out at the top has positive (+) camber. If it tilts in, it has negative (−) camber. The amount of tilt or camber angle is measured in degrees.

15. What is Caster?

Answer: Caster is the tilt of the steering axis toward the front or rear of the vehicle. If the tilt is toward the front, the wheel has negative (−) caster. A rearward tilt provides positive (+) caster. Caster is measured in degrees.

16. What is Brake fluid?

Answer: Brake fluid is a chemically inert hydraulic fluid used to transmit force and motion. It also lubricates the positions in the master cylinder, wheel cylinders and calipers. There are three types of brake fluid.

These are classified by the Department of Transportation (DOT) as DOT 3, DOT 4 and DOT 5. This classification must appear on the brake-fluid container.

17. What is the Purpose of antilock braking system (ABS)?

Answer: Tires skid when they slow or decelerate faster than the vehicle. One way to prevent skidding is to keep the brakes from locking. This is the purpose of antilock braking system (ABS).

18. Describe tire size and sidewall marking P205/60HR15.

Answer: P205 means passenger type tire having section width of 205 mm.

60 is the aspect ratio (sectional height / sectional width)

H is the speed rating (maximum 210 km/h).

15 is the diameter of the wheel in inches.

19. What is Toe?

Answer: Toe is the measurement of how much the wheels point in or out from the straight-ahead position.

অধ্যায় ১০

Difference Dot Com

Impulse Turbine	Reaction turbine
a) The working fluid first flowing through the nozzle and then through the moving vane.	a) The working fluid first flowing through guide vane and then through the moving blade.
b) The working fluid impinges on the moving blade with kinetic energy.	b) The working fluid impinges on the moving blade with kinetic energy as well as pressure energy.
c) It may or may not be admitted over the whole circumference.	c) It must be admitted over the whole circumference.
d) The pressure of working fluid is reduced while passing through the nozzle and remains constant while passing through moving blade.	d) The pressure of working fluid is reduced in fixed blades as well as moving blades.
e) The velocity of working fluid is increased while passing through the nozzle and reduced while passing through the moving blades.	e) The velocity of working fluid is increased in fixed blade and reduced in moving blades.
f) Used for high head of water.(250m-450m)	f) Used for low head of water.(0m-250m)
g) Pelton turbine	g) Kaplan (0-25m) and Francis (25m-250m)

Centrifugal Pump	Reciprocating Pump
a) The discharge is continuous and smooth.	a) The discharge is fluctuating and pulsating.
b) It can handle large quantity of liquid.	b) It can handle small quantity of liquid.
c) It is used for large discharge through small head.	c) It is used for small discharge through large head.
d) Runs at high speed.	d) Runs at low speed.
e) Efficiency is ~~high.~~ low	e) Efficiency is ~~low.~~ high
f) Need smaller area and installation cost is low.	f) Installation cost high and need large area.
g) Low maintenance cost.	g) High maintenance cost.
h) Used for lifting low viscous fluid.	h) It can be used for lifting highly viscous fluid.
i) Cost of centrifugal pump is less as compared to reciprocating pump.	i) Cost of reciprocating pump is high compared to centrifugal pump.
j) $Q = \pi D b V_f$ Where, D- dia of impeller at inlet, b-width of impeller at inlet, V_f- Velocity of flow at inlet. $P = wQH_m/\eta_o$ w- Sp. wt. of water in (KN/m^3), H_m= Manometric head in (m), η_o- overall efficiency of the pump.	j) Q= LAN/60 Where, L- length of stroke in meter, A=cross-sectional area at piston, N-Speed of the crank. $P = wQ(H_s+H_d)$

Supercharger	Turbo Charger
a) Super Charger compressor is driven by the engine power.	a) Turbo charger is driven by the energy from engine exhaust gases.
b) As the running power comes from engine power so it is less efficient.	b) As the running power comes from engine exhaust so it is more efficient.
c) For faster speed but not for fuel economy supercharger is used.	c) For better fuel economy turbo charger is used.
d) Easier to control.	

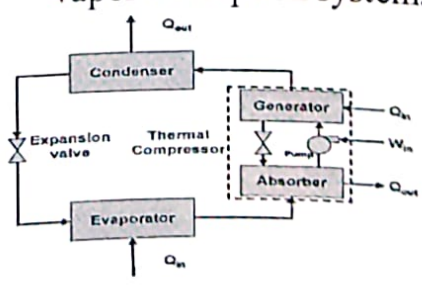
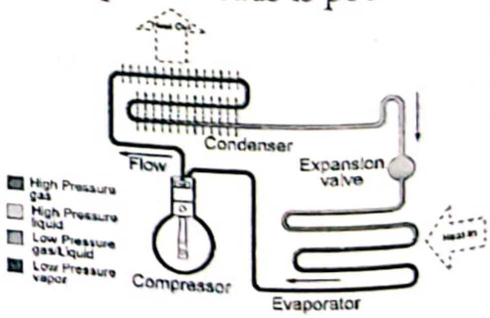
e) As it is driven by engine power so after starting the engine it also starts. f) More space is required.	d) Difficult to control. e) But for starting the turbo charger it has a little bit delay, it is called turbo lag. f) Less space is required.

Water Tube Boiler	Fire Tube Boiler
a) The water circulates inside the tubes which are surrounded by hot gases from the furnace.	a) The hot gases from the furnace pass through the tubes which are surrounded by water.
b) It generates steam at a highest pressure upto 165bar.	b) It can generate steam only upto 24.5 bar.
c) The rate of generation of steam is high i.e. upto 450 tonnes per hour.	c) The rate of generation of steam is high i.e. upto 9 tonnes per hour.
d) For a given power, the floor area required for the generation steam is less, i.e. about 5 m^2 per tonne per hour of steam generation.	d) For a given power, the floor area required for the generation steam is less, i.e. about 8 m^2per tonne per hour of steam generation.
e) Overall efficiency will economizer is upto 90%.	e) Overall efficiency will economizer is upto 75%.
f) It can be transported and erected easily as its various parts can be separated.	f) The transportation and erection is difficult.
g) It is preferred for widely fluctuating loads.	g) It can also cope reasonably with sudden increase in load but for a shorter period.
h) The direction of water circulation is well defined.	h) The water does not circulate in a definite direction.
i) The operating cost is very high.	i) The operating cost is less.
j) The bursting changes are more.	j) The bursting changes are less.
k) The bursting does not produce any destruction to	k) The bursting produces greater risk to the damage

the whole boiler. l) It is used for large power plants.	of the property. l) It is not suitable for large power plants.

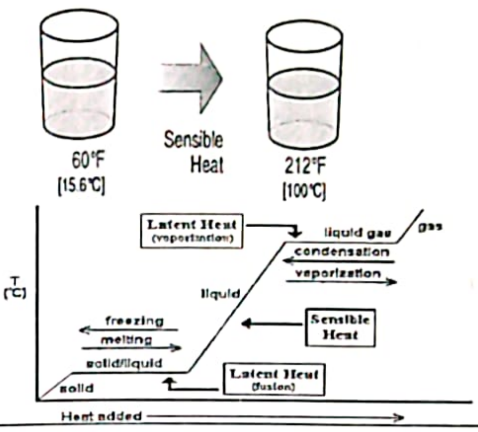
Petrol Engine	Diesel Engine
a) A petrol engine draws a mixture of petrol and air during suction stroke.	a) A diesel engine draws only air during suction stroke.
b) The carburetor is employed to mix air and petrol in the required proportion and to supply it to the engine during suction stroke.	b) The injector or atomizer is employed to inject the fuel at the end of compression.
c) Pressure at the end of compression is about 10 bar.	c) Pressure at the end of compression is about 35 bar.
d) The charge (i.e. petrol and air mixture) is ignited with the help of spark plug.	d) The fuel is injected in the form of fine spray. The temperature of the compressed air (about 600°C at the pressure of about 35 bar) is sufficiently high to ignite the fuel.
e) The combustion of fuel takes place approximately at constant volume. In other words, it works on Otto cycle.	e) The combustion of fuel takes place approximately at constant pressure. In other words, it works on Diesel cycle.
f) A petrol engine has compression ratio approximately from 6 to 10.	f) A diesel engine has compression ratio approximately from 15 to 25.
g) The starting is easy due to low compression ratio.	g) The starting is difficult due to high compression ratio.
h) As the compression ratio is low, the petrol engines are lighter and cheaper.	h) As the compression ratio is higher, the diesel engines are heavier and costlier.
i) The running cost of a petrol engine is high because of the higher cost of petrol.	i) The running cost of a diesel engine is low because of the lower cost of diesel.
j) The maintenance cost is less.	J) The maintenance cost is more.
k) The thermal efficiency is upto about 26%.	k) The thermal efficiency is upto about 40%.
l) Overheating trouble is more due to low thermal efficiency.	l) Overheating trouble is more due to high thermal efficiency.
m) These are high speed engines.	m) These are relatively low speed
n) The petrol engines are generally employed in light duty vehicles such as scoters,	

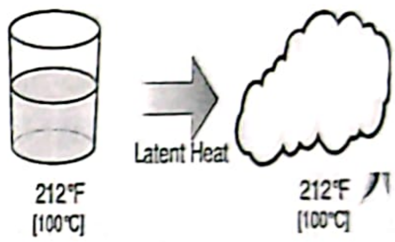
motorcycles, cars. They are also used in aero planes.	engines. n) The diesel engines are generally employed in heavy duty vehicles such as buses, trucks and earth moving machines.

Vapor Absorption RS	**Vapor Compression RS**
a) In vapor absorption refrigerating system the vapor is drawn from the evaporator by absorption into liquid having high affinity for the refrigerant. b) Instead of the compressor the system contains absorber, pump, and generator due to increase the pressure. c) It is subjected to little wear due to only moving part at pump. d) The system can operate at reduced evaporator pressure and temperature with a little decrease in capacity. e) The load variation does not affect the performance of a vapor absorption system.  	a) In vapor compression refrigerating system the vapor is withdrawn by a compressor from the evaporator. b) The system contains compressor due to increase the pressure. c) This system has more wear, tear and noise due to moving parts of the compressor. d) The capacity of this system drops rapidly with lowered evaporator pressure. e) The performance of a vapor compression system at partial loads is poor. 

Carburetor	Fuel injector
Carburetor working mechanism involves the Venture effect taking place in a narrow section called throat of carburetor, where increase in the air speed result in a drop of pressure in the air flow.	Fuel injector working mechanism involves the fuel is sucked out of a supply container through a small opening while whereas in electric control fuel injection, the air fuel mixture is prepared after electronic devices have made all calculation according to engine requirement
Carburetor fuel consumption cannot be optimized because of its working phenomena	Due to fuel injector, fuel consumption can be optimized to suit the performance of the engine in fuel injectors, which increasing the efficiency and reducing the emissions.
Carburetor an air inlet through an air filter, after that there is chock valve and after passing it air pass through a throat in which it mix with fuel and then there is a throttle valve after which air fuel mixture pass into engine.	Construction of fuel injector consist of following things O-ring, filter, Electrical connector, Electrical Coil, Magnet, spring, O-ring, Valve and Pintle Cap.
Carburetor is a pure mechanical device.	Fuel injector could be pure mechanical or electrical device.

Sensible Heat	Latent Heat
1. When a substance is heated a net temperature rises as the heat is added or when heat is removed from a substance and the temperature falls as the heat is removed, the increase in heat or	1. The heat which brings about a change of state with no change in temperature is called latent heat.

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subtracted heat is called sensible heat.
2. Sensible heat must affect the temperature.
3. It occurs within only single phase of a substance.
4. For refrigeration, sensible capacity is the capacity required to lower the temperature.
5.


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2. Latent heat does not affect the temperature.
3. It occurs at the time of changing the phase of a substance.
4. For refrigeration, latent capacity is the capacity to remove the moisture from the air.
5.


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Synchronous Motor (S.M)	Induction Motor (I.M)
1. Operating speed is constant. 2. Synchronous motors are not self-starting. 3. S.M. operates with load having lagging, leading & unity power factor. 4. An additional dc excitation is required.	1. Operating speed is variable. 2. Induction motors (3phase) are self-starting. 3. I.M operates with load having only lagging power factor. 4. No dc excitation is required.

D.C. Motor	A.C motor / I.M.
1. DC motors are direct	1. AC motors are

current motors. 2. DC motor receives power by conduction. 3. Here armature is rotating part and field system is stationary. 4. Dc motors are self-starting. **5.** It requires brush and commutator.	alternating current motors. 2. AC motor receives power by induction. 3. Here armature is stationary and field system is rotating. 4. Ac motor requires effective starting equipment. 5. It requires no brush and commutator. (I.M)

DC generator	**AC generator / Alternator**
1. Generates constant E.M.F. at its terminals. 2. In dc generators, the armature rotates and the field system is stationary. **3.** DC generator uses all the energy that is produced.	1. Generates alternating E.M.F. at its terminals. 2. In alternators, the armature is stationary and the field system is rotating. 3. Alternators conserve energy by using only the energy that is needed.

Introduce Yourself

এখানে কয়েকটা নমুনা দেওয়া হলো। এটা দেখে আপনি পরের পৃষ্ঠায় পেন্সিল দিয়ে আপনার সম্পর্কে লিখে ফেলুন। পেন্সিল দিয়ে লিখবেন কারণ পরবর্তিতে আবার আপডেট করতে পারবেন।

Ex1: First of all, thank you very much for giving me this opportunity. I am Atiq Rahman and I'm from Naogaon. In 2012, I had completed my engineering in Mechanical Engineering from Rajshahi University of Engineering and Technology with a first class degree. During my Graduation period, I had done three Mainframe projects and successfully completed two training courses on the auto CAD and Solid Works. My *hobbies* are drawing the designs & article writing. During my student life I have organized different types of events in our department and worked together with some social welfare groups. I have just started my career and don't have any working experience, but once I get the opportunity, I will try to prove myself.

Ex2: I am Fahad Hossain, son of Abdur Rahim and Mrs. Shehnaz Parvin. Recently I completed my graduation from KUET and my earlier study I had done in my hometown Rangpur. My Academic results are always fair and I never fail in any subject. I have already worked with some projects in the field of Mechanical which you can see in my resume. I wrote one project papers and one of them published in KUET. My hobbies are reading and solving machine tool works. That's why this type of job always attracts me. Thank you so much, sir.

Ex3: I am Zubayer Arman. I am from Natore and my five member of family are there. I am here for my job perpose. I am working at ZNT for two years as an junior PD. I took a course on the design of solar water heating systems a few months ago. As the future of energy moves toward solar, I wanted to be familiar with the components and processes of using solar collector systems to generate energy. A lot of what I learned can be applied to other forms of solar absorption

construction.But there I don't get the opportunity to implement my ability that's why I think, this job can give me the chance to go forward with it.

Ex4: I'm Rohan Mitra. I completed my B.Sc from CUET and I've been working as a mechanical engineer for the past 2.5 years in XYZ Power Company. They have a 100MW engine based power plant. All of the engines are of MAN and each of them is 13MW. I have took part two engine overhauling works and successfully run the plant. Moreover, I take regular data of pump vibration, cooling system parameters and analysis them.

I am interested in joining your company as an senior assistant engineer. Besides, I like to read and watch videos that explain the tips and tricks which are applied to construct any project. That's all for me.

Introduce Yourself

<u>নিজ জেলার গুরুত্বপূর্ণ তথ্যগুলো লিখে ফেলুন</u>

আরো গুরুত্বপূর্ণ কিছু তথ্য যা ভাইভার আগে দেখা দরকার

যদিও বইটির প্রায় ৪৫০টি প্রশ্ন বিভিন্ন ভাইভার অভিজ্ঞতার আলোকে সংযোজন করা হয়েছে তবুও এখানে কয়েকটা বাস্তব অভিজ্ঞতা আলোচনা করা হলো।

NWPGCL ভাইভার অভিজ্ঞতা

এটা আমার প্রথম সরকারি ভাইভা ছিল।

প্রার্থীঃ (দরজা খুলে ভিতরে ঢুকে) আসসালামু আলাইকুম স্যার।
সম্মানিত বোর্ড মেম্বার-১ঃ আসো। বসো।
প্রার্থী তার আসন গ্রহণ করলো।
সম্মানিত বোর্ড মেম্বার-১ঃ এমরান হোসেন। তোমার বাবা কি করেন?
প্রার্থীঃ গ্রামে আমাদের ছোট একটা মুদি দোকান আছে স্যার। উনি ওখানেই কাজ করেন।
সম্মানিত বোর্ড মেম্বার-২ঃ আচ্ছা, তুমি পাশ করছো কবে?
প্রার্থীঃ স্যার ২০1৪ সালের ডিসেম্বরে।
সম্মানিত বোর্ড মেম্বার-২ঃ এখন কি করছো?
প্রার্থীঃ স্যার, হরিপুর পাওয়ার লিমিটেড, (পেন্ডেকার এনার্জির ৩৬০ মে.গা. কম্বাইন্ড সাইকেল পাওয়ার প্ল্যান্টে আছি)
সম্মানিত বোর্ড মেম্বার-৩ঃ হরিপুর এটা কোথায়? সিলেট?
প্রার্থীঃ নাহ স্যার। এটা নারায়ণগঞ্জ।
সম্মানিত বোর্ড মেম্বার-৩ঃ নারায়ণগঞ্জ কেন বিখ্যাত?
প্রার্থীঃ স্যার, সোনারগাঁ এর জন্য?
সম্মানিত বোর্ড মেম্বার-৩ঃ সোনারগাঁ কেন বিখ্যাত?
প্রার্থীঃ স্যার, এটা এক সময় বাংলার রাজধানী ছিল। সম্ভবত ঈশা খাঁর সময়।
সম্মানিত বোর্ড মেম্বার-৩ঃ ওই সময়ের আরো বিখ্যাত কিছু স্থাপনার নাম বলো।
প্রার্থীঃ গ্রান্ড ট্রাঙ্ক রোড।
সম্মানিত বোর্ড মেম্বার-৩ঃ উচ্চারণ ভালো করে বলো।
প্রার্থী চেষ্টা করলো কিন্তু সম্ভবত সঠিক বলতে পারলো না ।
সম্মানিত বোর্ড মেম্বার-১ঃ ওই সময় একটা বাঁধ ছিল। বলতে পারবে কোন বাঁধ?
প্রার্থীঃ খানিকটা ভেবে বললো নাহ স্যার, পারবো না।
(সম্ভবত বাকল্যান্ড বাঁধের কথা জানতে চাচ্ছিলেন)
সম্মানিত বোর্ড মেম্বার-২ঃ হরিপুর ছেড়ে এখানে আসতে চাচ্ছো কেন? ওটাও তো অনেক ভালো।
প্রার্থীঃ স্যার, ওটা এখনো পারমানেন্ট জব নয় আর তাছাড়াও নর্থ ওয়েস্ট অনেক বড় পাওয়ার প্লান্ট।
সম্মানিত বোর্ড মেম্বার-৪ঃ পাওয়ার প্লান্ট? !
প্রার্থীঃ সরি স্যার, পাওয়ার জেনারেশন কোম্পানী।

সম্মানিত বোর্ড মেম্বার-২ঃ আচ্ছা, তোমার প্লান্টের গ্যাস টার্বাইনের মডেল কত?
প্রার্থীঃ স্যার, আপনাদের সিরাজগঞ্জের প্লান্টের মতই M701F.
সম্মানিত বোর্ড মেম্বার-২ঃ আচ্ছা। কম্বাইন্ড সাইকেল কেন বলে?
প্রার্থীঃ স্যার, এখানে দুইটা সাইকেল থাকে। একটা গ্যাস টার্বাইন এবং একটা স্টিম টারবাইন। গ্যাস টার্বাইনের একজস্ট গ্যাসকে কাজে লাগিয়ে স্টিম তৈরি করা হয় এবং সেই স্টিমকে কাজে লাগিয়ে একটা স্টিম টার্বাইন চলে। যেহেতু দুইটার কম্বিনেশনে চলে তাই একে কম্বাইন্ড সাইকেল বলে।
সম্মানিত বোর্ড মেম্বার-২ঃ স্টিম টার্বাইন কোন সাইকেলে চলে?
প্রার্থীঃ র‍্যাংকিন সাইকেলে।
সম্মানিত বোর্ড মেম্বার-২ঃ এটার T-S Diagram টা draw করো।
প্রার্থী draw করলো।
সম্মানিত বোর্ড মেম্বার-২ঃ এখানে পাম্প কোনটা?
প্রার্থীঃ (পাম্পের অংশ দেখালো।) এটা স্যার।
সম্মানিত বোর্ড মেম্বার-৪ঃ তোমাদের জেনেরেটরের আউটপুট কত?
প্রার্থীঃ স্যার, গ্যাস টার্বাইন জেনেরেটর ১৬ কেভি আর স্টিম জেনেরেটরের ১১ কেভি।
সম্মানিত বোর্ড মেম্বার-৪ঃ গ্রিডে কত ভোল্টেজ দাও?
প্রার্থীঃ স্যার, ২৩০ কেভি স্যার।
সম্মানিত বোর্ড মেম্বার-৪ঃ আর কিছু বলবেন আপনারা? (অন্য স্যারদের দিকে তাকিয়ে)
অন্য স্যাররাঃ নাহ।
সম্মানিত বোর্ড মেম্বার-১ঃ ঠিক আছে। তুমি আসো।
প্রার্থী উঠে সালাম দিতে যাবে এই সময় আরো একজন স্যার প্রবেশ করলেন। [প্রশ্নকর্তা চারজন ছাড়াও ভিতরে আরো একজন বোর্ড মেম্বার ছিলেন।]
সম্মানিত বোর্ড মেম্বার-৫ঃ বসো, বলোতো টিউব আর পাইপের মধ্যে পার্থক্য কি?
প্রার্থীঃ এই রকম পরিস্থিতিতে হতচকিত হয়ে কিছু একটা বললো।
সম্মানিত বোর্ড মেম্বার-৫ঃ এই রুমে কোন পাইপ বা টিউব আছে নাকি?
(প্রার্থী উত্তর দেওয়ার আগেই রুমের স্টান্ড ফ্যানের স্ট্যান্ড দেখিয়ে বললেন- আচ্ছা, বলো, এটা কি পাইপ নাকি টিউব?)
প্রার্থীঃ স্যার, এটা পাইপ।
সম্মানিত বোর্ড মেম্বার-৫ঃ শোনো, ভালো করে পড়াশোনা করবে। ভালো করে পড়ে আসবে। যাও।
প্রার্থীঃ আসসালামু আলাইকুম স্যার।
প্রার্থী হতাশ হয়ে বের হয়ে আসলো।

BAPEX ভাইভার অভিজ্ঞতা

প্রার্থীঃ (দরজা খুলে ভিতরে ঢুকে) আসসালামু আলাইকুম স্যার।
সম্মানিত বোর্ড মেম্বার-১ঃ আসো। বসো।
প্রার্থী তার আসন গ্রহণ করলো।
সম্মানিত বোর্ড মেম্বার-২ঃ এমরান হোসেন, তুমি পাশ করছো কোথায় থেকে?
প্রার্থীঃ স্যার রুয়েট থেকে।
সম্মানিত বোর্ড মেম্বার-২ঃ এখন কি করছো?
প্রার্থীঃ স্যার, হরিপুর পাওয়ার লিমিটেড, (পেন্ডেকার এনার্জির ৩৬০ মে.গা. কম্বাইন্ড সাইকেল পাওয়ার প্ল্যান্টে আছি স্যার)
স্যাররা নিজেদের মধ্যে আলাপ করছিলেন পেন্ডেকার কোনটা তাই নিয়ে। সম্ভবত বুয়েটের সম্মানিত একজন স্যার পেন্ডেকার সম্পর্কে বলছিলেন।
সম্মানিত বোর্ড মেম্বার-৩ঃ তোমাদের গ্যাস টার্বানের গ্যাস কে সাপ্লাই দেয়।
প্রার্থীঃ স্যার, তিতাস গ্যাস।
সম্মানিত বোর্ড মেম্বার-২ঃ গ্যাস টার্বাইনের কম্বাশন চেম্বারে কত তাপমাত্রা থাকে?
প্রার্থীঃ স্যার, আমরা আমাদের ডিসিএস সিস্টেমে ১৪০০ ডিগ্রি সেলসিয়াসের মত দেখতে পাই।
সম্মানিত বোর্ড মেম্বার-২ঃ আচ্ছা, তোমাদের বয়লারের ক্যাপাসিটি কত?
প্রার্থীঃ স্যার, এখানে বয়লার বলতে এইচআরএসজি। এখানে তিনটা আলাদা প্রেসারের স্টিম সাপ্লাই দেওয়া হয়। হাই প্রেসার ২৫৬টন/আওয়ার, রিহিট ৩০০ টন/আওয়ার, আর লো প্রেসার ৫০ টনের কাছাকাছি।
সম্মানিত বোর্ড মেম্বার-৩ঃ আচ্ছা, বীরশ্রেষ্ঠ কয়জন?
প্রার্থীঃ স্যার ৭জন।
সম্মানিত বোর্ড মেম্বার-৩ঃ নাম বলো।
প্রার্থীঃ ছয় জনের নাম বলার পর, আরো একজন বলতে দেরি হচ্ছিলো।
সম্মানিত বোর্ড মেম্বার-৩ঃ আচ্ছা হয়েছে। আমি বললে একবারে চার পাঁচ জনের বেশি মনে করতে পারি না, একটু সময় লাগে।
সম্মানিত বোর্ড মেম্বার-৪ঃ বলোতো, ইন্ডাস্ট্রিতে কত ডেসিবেলের বেশি শব্দ তৈরি করার আইন নাই।
প্রার্থীঃ স্যার ১০০ ডেসিবেল।
সম্মানিত বোর্ড মেম্বার-৪ঃ এত বেশি? আচ্ছা, তাহলে বলো মানুষের কথায় কত ডেসিবেল উৎপন্ন হয়?
প্রার্থীঃ স্যার, ঠিক বলতে পারবো না।
সম্মানিত বোর্ড মেম্বার-৪ঃ পিএম মানে পারটিকুলেট মেটার। এটা 'কি' বলতে পারবে?
প্রার্থীঃ পিপিএম।

সম্মানিত বোর্ড মেম্বার-৪ঃ না না। পিএম। পিপিএম না। ওটা তো পার্টস পার মিলিয়ন।
প্রার্থীঃ হ্যাঁ স্যার।
সম্মানিত বোর্ড মেম্বার-১ঃ আচ্ছা। ঠিক আছে। আসো।
প্রার্থীঃ আসসালামু আলাইকুম স্যার।

PGCL ভাইভার অভিজ্ঞতা

এই ভাইভায় আমার চাকুরি হয়েছিল

প্রার্থীঃ (দরজা খুলে ভিতরে ঢুকে) আসসালামু আলাইকুম স্যার।
সম্মানিত বোর্ড মেম্বার-১ঃ আসো। বসো।
প্রার্থী তার আসন গ্রহণ করলো।
সম্মানিত বোর্ড মেম্বার স্যাররা নিজেদের মধ্যে লিস্টে আমার নাম দেখিয়ে কিছু একটা আলোচনা করছিলেন।
সম্মানিত বোর্ড মেম্বার-২ঃ এমরান হোসেন, তুমি পাশ করছো কোথায় থেকে?
প্রার্থীঃ স্যার রুয়েট থেকে।
সম্মানিত বোর্ড মেম্বার-২ঃ এখন কি করছো?
প্রার্থীঃ স্যার, হরিপুর পাওয়ার লিমিটেড, (পেন্ডেকার এনার্জির ৩৬০ মে.গা. কম্বাইন্ড সাইকেল পাওয়ার প্ল্যান্টে আছি স্যার)
সম্মানিত বোর্ড মেম্বার-৩ঃ তোমরা গ্যাস কোথা থেকে নাও?
প্রার্থীঃ স্যার, তিতাস গ্যাস।
সম্মানিত বোর্ড মেম্বার-৩ঃ তিতাস গ্যাসের প্রেসার কত থাকে?
প্রার্থীঃ স্যার, ১০/১১ বারের মত।
সম্মানিত দুইজন স্যার এটাকে পিএসআইয়ে কনভার্ট করছিলেন আর বলছিলেন এটা আমাদের মতই।
সম্মানিত বোর্ড মেম্বার-২ঃ তোমাদের ওখানে কোনো বুস্টার কম্প্রেসর আছে কি?
প্রার্থীঃ হ্যাঁ স্যার। আছে। দুইটা সেন্ট্রিফুগ্যাল গ্যাস কম্প্রেসর আছে । একটা চালু থাকে আর একটা স্ট্যান্ডবাই থাকে।
সম্মানিত বোর্ড মেম্বার-২ঃ এখানে কত প্রেসার রাইজ করে?
প্রার্থীঃ স্যার ৩০ বারের মত।
সম্মানিত বোর্ড মেম্বার-৪ঃ তোমার বাড়ি কোথায়?
প্রার্থীঃ নওগাঁ জেলায়।
সম্মানিত বোর্ড মেম্বার-৪ঃ এখানে কি একটা বিহার আছে না?
প্রার্থীঃ হ্যাঁ। সোমপুর বিহার।
সম্মানিত বোর্ড মেম্বার-৪ঃ এটা কেন বিখ্যাত?
প্রার্থীঃ স্যার এটা এক সময় বৌদ্ধ বিহার ছিল। এটা ধর্মপালের আমলে তৈরি। ৮ম খ্রিষ্টাব্দে।
সম্মানিত বোর্ড মেম্বার-৪ঃ খ্রিষ্টাব্দ? নাকি খ্রিষ্টপূর্ব?
প্রার্থীঃ খ্রিষ্টাব্দ।

সম্মানিত বোর্ড মেম্বার-১ঃ আচ্ছা তোমার এখানে চাকুরি হলে তুমি পাওয়ার প্ল্যান্ট ছেড়ে এখানে আসবে?
প্রার্থীঃ হ্যাঁ, স্যার। আমি সরকারি চাকুরির জন্য চেষ্টা করছিলাম। এটা হলে চলে আসবো।
সম্মানিত বোর্ড মেম্বার-১ঃ ঠিক আছে। এখন আসো।